
Del Cimento
LONDON
Printed for Benj. Allsop at the Angell &
Bible in the Poultry

ESSAYES
OF
Natural Experiments
Made in the
ACADEMIE DEL CIMENTO,
Under the Protection of the
Most SERENE PRINCE
LEOPOLD of *TUSCANY.*

Written in Italian *by the Secretary of that* ACADEMY.

Englished by *RICHARD WALLER,*
Fellow of the *Royal Society.*

LONDON,
Printed for *Benjamin Alsop* at the *Angel* and *Bible* in the *Poultrey*, over-against the *Church.* 1684.

To Sir John Hoskyns *Knight and Baronet*, Preſident *of the* Royal Society, *&c.*

SIR,

AS your Commands gave the firſt being to this Attempt, ſo 'tis but Juſtice to offer it to your Self; and 'twas but neceſſary to crave ſo advantagious a Protection, to defend it againſt the Difficulties, things of this Nature meet with, in this Cenſorious Age.

I ſhall wave, as leſs grateful to you, a large Deſcription of the Happineſs the *Royal Society* enjoys under ſuch a *Preſident*, whoſe perſpicacious Judgment is actuated by a true deſire of promoting real Knowledge; and ſhall rather give ſome account of the Work it ſelf: It was preſented in a Publique Meeting of the *Royal*

Society

Society, *March* 12. $166\frac{7}{8}$ by Sig^r. *Lorenzo Magalotti*, and Sig^r. *Paulo Falconieri*, from the Moſt Serene Prince *Leopold*, Brother to *Ferdinand* the Second, *Great Duke of Tuſcany*; and has ever ſince layn in our *Library* expecting a more skilful Pen, to perform what I have here aimed at. The *Experiments* are many, and curious, made under the favour of that Prince, by the Members of the *Academy Del Cimento*, men of great ingenuity; and related with much ſincerity by the *Secretary* of that *Academy*; which *Society* (I hear) is now ſcatter'd, and the Hopes of thoſe Benefits the Learned World might juſtly expect from them, fruſtrated. Many indeed of theſe *Experiments* have been made, and ſhewn in ſeveral Meetings of the *Royal Society* (before, and ſince the Publication of this in the *Italian*, in the Year 1667) by the Honourable

Honourable *Robert Boyle*, Eſq; and other worthy Members thereof; but for all this, I hope it may not prove unacceptable to find the Ingenious in other Parts of the World, have not thought their time miſpent in theſe Endeavours, what contrary Sentiments ſoever ſome may have; nor will the agreement between the ſucceſs of *Experiments* made there, and what has been attempted here (often with a differing *Apparatus*) be leſs pleaſing: very many, I dare undertake, are New to moſt Perſons, except your ſelf, and upon that account will prove more diverting. I need not add the great Expence of Care, and Charge, and Fatigues of the *Academy* in this Work; nor the ſcarcity of this Piece in the Original, no ſmall Motive to this Undertaking (that it might be obtained with more Eaſe, and at a cheaper Rate;) which how performed, I ſubmit to your Self, and

the

the worthy Members of the most Illustrious *Royal Society*; begging Pardon for this Presumption; desiring onely to subscribe my self,

SIR,

Your most humble Servant,

Richard Waller.

To

To the Most SERENE

Ferdinand II.

GRAND DUKE of *TUSCANY*.

Most SERENE PRINCE,

THE Publishing of these First Essays of *Natural Experiments*, which for many Years have been made in our *Academy*, under the Protection, and with the Indefatigable Assistance of the most Serene Prince *Leopold* your Highness's Brother, will prove the happy occasion of giving fresh Testimonies (of your Highness's great Liberality) to all those parts of the World where Vertue is adorn'd with its deserved Lustre; and will create a new sense of Gratitude and Respect in all true Lovers of the more curious Arts, and Nobler Sciences. Especially we ought to frame our thoughts to a more humble Acknowledgment, as we are more nearly concerned and warmed by the cherish-

ing Rays, and invigorating Influence of your Highneſs's bounty. Which with the favour of your Patronage, the incouraging invitation of your Mind, and proper Genius that way; but above all, with the Honour of your Preſence, ſometimes ſtooping to our *Academy*, ſometimes commanding us to your Royal Apartments, has beſtowed upon it an Immortal Name; Kindled Active Deſires in our Breaſts, and given an happy encreaſe to our Studies. Theſe conſiderations eaſily demonſtrate, with what duty we are engaged to Conſecrate the firſt Fruits of our Labours to your Highneſs's moſt Illuſtrious Name; ſince nothing can proceed from us, wherein you can have a greater ſhare, and by conſequence more due to you; nor any thing that may make fairer approaches to merit the happy Fate of your generous Acceptance. 'Tis certain, that through the Exceſs of ſo large and ſignal Favours, we can be ſenſible of no greater Reſentments than to find our ſelves ſo much obliged to your Highneſs: not that we refuſe to bear the Weight of ſo endearing and ineſtimable an Obligation; but onely becauſe we would wiſh to be able to offer ſomething not

purely

purely your own; whence we might at leaſt flatter our ſelves, That we had made ſome ſmall return which your Highneſs might impute in ſome degree to our choice, and not wholy redewable to your Highneſs Self, or Neceſſity. But we muſt reſt ſatisfied with the bare deſire of ſo juſt and deſerved a Paſſion; ſince theſe new *Philoſophical* Speculations are ſo deeply Radicated in your Highneſs's Protection, that not onely what is now produced by our *Academy*, but what ever ſhall be brought to Maturity in the moſt Famous Schools of *Europe*, or After Ages raiſe up, ſhall be likewiſe due to your Highneſs, as the gift of your Beneficence: ſince as long as the *Sun*, *Planets*, and *Stars* retain their glory, and *Heaven* endures, there will remain a glorious Memory of one that contributes ſo much with his auſpicious Influence to ſuch new and ſtrange Diſcoveries; opening an unbeaten Path for the leaſt fallacious Method of ſearch after Truth. Yet in ſo great a ſcarcity of Tributes, ſome little thing preſents it ſelf to manifeſt our grateful obſervance; which is the onely joy wherewith we ſupport our Deficiency, while all redounds in more reſplendant Glory to your

Highneſs, who having already acted your full Proportion of what ever new, good, and great, is at any time to be found in the Repoſitory of Sciences, has enervated and diſcouraged all thoughts of emulation in others. This, and this alone are we able to lay at your Highneſs Feet, whoſe continual Protection we crave with Reſpect and Reverence, begging from Heaven the height of Proſperity and Grandure to your Highneſs.

Your moſt Serene Highneſs's

Florence *July* 14*th.* 1667.

Moſt humble Servants

Of the Academy Del Cimento.

Il Saggiato Segretario.

THE

THE PREFACE TO THE READER.

AMong *all the Creatures of Divine Wiſdom, the Birthright doubtleſs belongs to the* Idea *of Truth, which the Eternal Artificer ſo exactly followed in the Univerſal Fabrick of Nature, That no* Being *was made with the leaſt irregular Bias of falſhood: But Man afterwards, (in the Contemplation of ſo high and perfect a Structure, through an extravagant deſire of Comprehending the admirable Deſign, and finding out all the Meaſures and Proportions of ſo Beautiful an Order) when he aims to penetrate too deep into the Truth, frames to himſelf an indefinite number of falſities, which proceeds from no other cauſe but his Ambition to take thoſe Wings Nature never deſign'd*

design'd (perchance fearing to be some time or other discovered by him unwittingly in the preparation of her greater Works;) yet upon these he begins to raise himself, and tho charged with the weight of a Material Body, stretches forth these Pinions to soar higher than the Scale of Sense leads, and fixes himself upon that Light, whose Rays, too powerful for his Eyes dazle, and blind him. Thus we see from Mans Rashness, the first Seeds of false Notions came; from which yet it happens, not that the bright Splendor of Gods Excellent Creatures is at all shaded, or by their Commerce with them in the least vitiated: since all these Imperfections are to be Attributed to Mans Ignorance, vitiated whence they had their Beginnings; when improperly applying the Causes to the Effects, he takes not from either the verity of their Beings, but onely delineates in his own mind a false Conception of their Relation to each other, and agreement; not that the soveraign Beneficence of God when he Creates our Souls, denies them to pry, as we may say for a Moment into the Immense Treasure of his Eternal Wisdom; adorning them as with the most precious Jewels, *with some first Sparks of Truth,*

Truth, ſufficiently evident from their retaining Notions not to be acquired here, whence we muſt conclude, They received them from ſome other Place.

But it happens through our Misfortune, that theſe rare Gems, as they are but looſely ſet in the Mind, yet too tender when ſhe firſt falls into her Earthly Habitation, and wraps her ſelf in this Clay; ſo for a time they fall out of their Collets, are ſullyed, and worth nothing till by aſſiduous and careful Study, they are again reſet in their proper places. This is what the Mind attempts in the ſearch of Nature; wherefore we muſt Confeſs, we have no better means then Geometry, *which at firſt Eſſay hits the Truth, and frees at once from all doubts, and wearying Reſearches. And indeed ſhe leads into the way of* Philoſophical Speculations, *but at laſt leaves us; not that* Geometry *has not a large Field to expatiate in, and Travels not over all Natures Works; as they all ſubmit to thoſe* Mathematick Laws, *by which the Eternal Decree freely Rules, and Commands them; but becauſe we hitherto are unable to follow her in ſo long, and wide a Path onely a few ſteps. Now*

where

where we may not truſt our ſelves to go farther, we can relye on nothing with greater Aſſurance than the faith of Experience, which (like one that having ſeveral looſe and ſcattered Gems, *endeavours to fix each in its proper Collet) by Adapting the Effects to the Cauſes; and again the Cauſes to the Effects if not at firſt Eſſay, as* Geometry *yet at laſt ſucceeds ſo happily, that by frequent* Trying, *and* Rejecting, *ſhe hits the Mark. We ought then to proceed with much Circumſpection, leſt too great a relyance and truſt in Experience, turn us out of the way, and impoſe upon us; ſince it ſometimes falls out, that before the clear Truth appears to us, when the firſt more open Vailes of Deceit are taken off, we diſcover ſome cheating Appearances that indeed have ſome likeneſs, and Reſemblance of Truth: and theſe are the imperfect Lineaments that are ſeen through the laſt coverings that more nearly vail the lovely face of Truth; through the fine Web whereof ſhe ſometimes ſeems ſo plain and lively, that ſome might conclude, She was Nakedly Diſcovered.*

Provando. e Riprovando.

Here then we ought to carry our ſelves as Maſterworkmen, to diſcern between Truth and Error, and

the

the utmoſt perſpicacy of Judgment is but requiſite, to ſee well what really is, from what is not ; And to be the better able to perform this Task, doubtleſs 'tis neceſſary to have at ſome time or other ſeen Truth unvailed ; an Advantage they onely have ; who have had ſome taſte of the ſtudies of Geometry.

Nor is it of leſs uſe to ſearch among Experiments *already made, than to attempt New ones, if haply any may be found, that have at all diſguiſed the ſimple Face of Truth : wherefore 'tis aimed at in our* Academy, *beſides what has been Invented by us, to try alſo (either for Curioſity, or as we light upon them by chance) thoſe things which have been already done , or wrote off by others : obſerving too well, That under this Name of* Experiments, *frequent* Errors *have crept in, and been entertained.*

This was the firſt Motive to the perſpicacious and indefatigable Mind of the moſt Serene Prince Leopold *of* Tuſcany ; *who in the Receſs of thoſe daily Negotiations, and ſolicitous Cares that attend his High Quality, diverted into the rough Path of the Nobleſt* Sciences. *But his Highneſs's diſcerning Judgment eaſily foreſeeing that the Reputation of great* Authors *proves too often hurtful to the Studious,*

dious, who through too much Confidence, and Veneration of their Names, fear to call in queſtion what is delivered upon their Authority; wherefore he judges it an Undertaking worthy of his great Mind to confront with the moſt Acurate, and ſenſible Experiments, the force of their Aſſertions, and with the due rejection of Errors, and Embraceing of Realities, to make ſo deſirable, and ineſtimable a Preſent to thoſe that earneſtly wiſh for the diſcovery of Truth. Theſe prudent Inſtructions of our moſt Serene Patron, *received with due Reverence and Reſpect by our* Academy, *has not moved us to be indiſcreet Cenſurers of the Learned Pains of others, nor made us bold Obtruders of our own Sentiments for Truths, and diſcoveries of Abuſes: but it is our Principal Intent to incite others alſo to repeat with the greateſt ſeverity, and niceneſs, the ſame Experiments; as we have now adventured to do with thoſe of any other Perſon: Tho in Publiſhing theſe firſt Eſſays, we have, what we could abſtained therefrom, that we might by this due reſpect, gain upon the Adverſary to believe the ſincerity of our Impartial, and Reſpectful Thoughts. And to the full compleating of ſo generous and*

uſeful

uſeful an Undertaking, we deſire onely a free Correſpondence with thoſe ſeveral Societies that are diſperced throughout the more Illuſtrious, and Noted Parts of Europe: *That with the ſame deſign of attaining ſuch high Ends, ſo profitable a Commerce being in all parts round about promoted, we may all go on with equal freedom, enquiring as much as poſſible, and participating of the Truth: and for our parts, we will concur to this Work with the greateſt ſimplicity, and ingenuity; whereof 'tis no ſmall Argument, That when we have related the Experiments of others, we have ſtill mentioned the* Authors *Name, when known to us; and that we have often freely confeſſed, that ſuppoſition concerning ſome* Experiments, *which when put in practice we were never ſo ſucceſsful as to bring to Perfection. But above all, to prove clearly the unfeigned ſincerity of our Proceedure, let that Freedom ſuffice, wherewith we have ſtill communicated the* Eſſays *and* Experiments *themſelves to any that, Travelling by our Country, ſhewed any deſire, or reliſh of ſuch* Sciences, *moved either by a gentile Humor, Eſteem of Learning, or Spur of Curioſity; and that from*

the firſt time our Academy *was Founded in the Year* 1657, *when the greateſt part, if not all the* Experiments *were invented, whereof theſe* Eſſays *are now Publiſhed. If it ſhall happen, that among them there ſhall be any found, thought of before, or after the time they were made here by other Perſons, and made Publick, let us not be blamed for it, ſince we could neither know, nor ſee all things; ſo that no man ought to wonder at the lucky Accord of our Minds, and Inventions with other Mens; nor indeed will we, if we find thoſe of other Men agree with ours.*

Laſtly, *We are unwilling any ſhould imagine, That we pretend in this Publication, a Perfect Work; or in the leaſt, an Exact Module of a large* Experimental Hiſtory; *conſcious to our ſelves, that more Time, and greater Abilities are neceſſary to ſo vaſt a Deſign; as may be ſeen by the very* Titſe *we have prefix'd, onely of* Eſſays, *which we had never put forth, had we not been much urged thereto by Perſons Meriting from us, by their dear importunities, the Sacrifice of a Bluſh, for expoſing ſuch imperfect* Embrio's.

And now we will cloſe all with a Proteſtation,

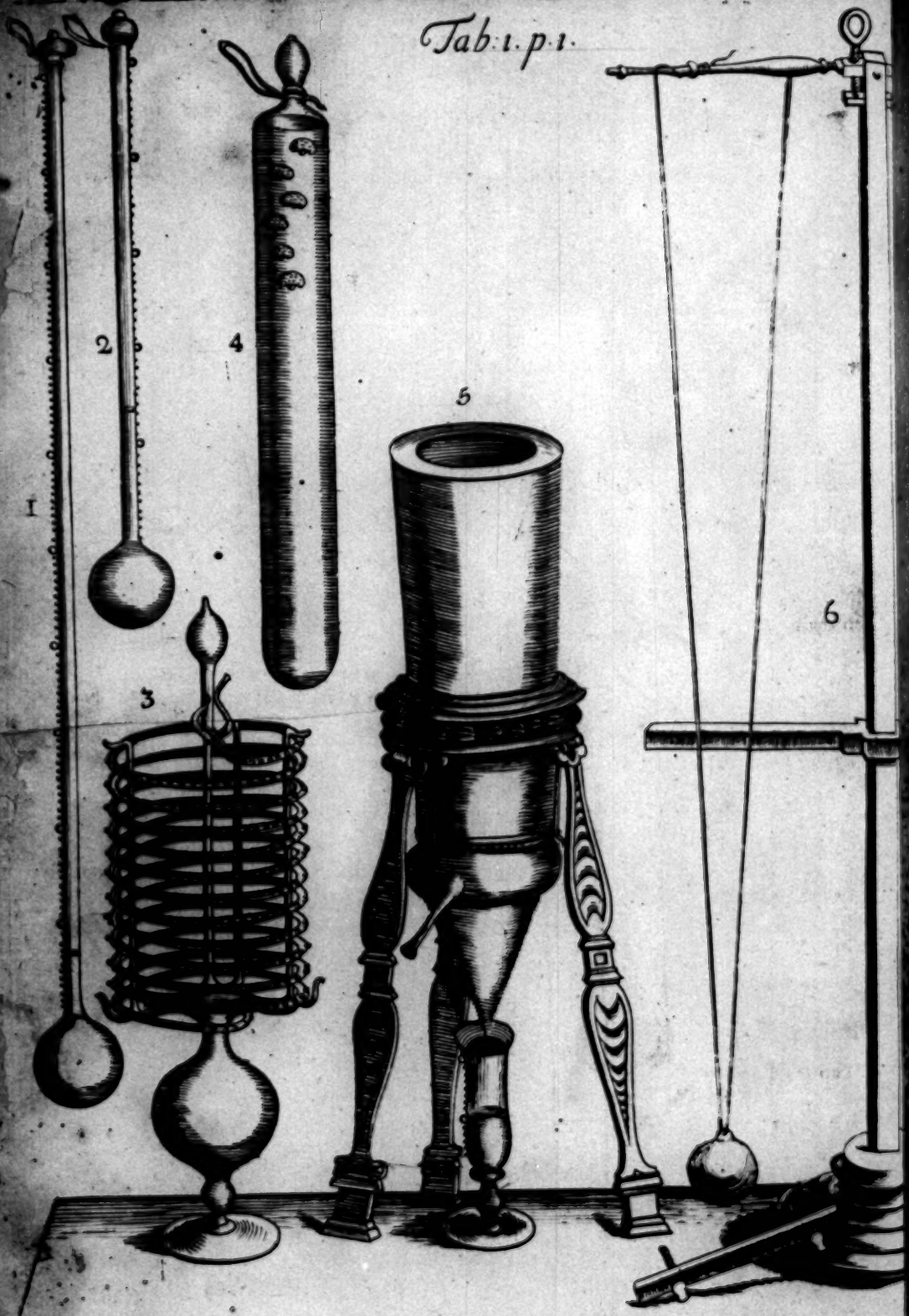
That

to the Reader.

That we never desire to entertain Controversie with any, or engage in any Nice Disputation, or heat of Contradiction; and if sometimes, as a Transition from one Experiment *to another, or upon what occasion soever, there shall be inserted any hints of Speculation, we Request they may be taken always for the thoughts, and particular sense of some one of the Members, but not imputed to the whole* Academy, *whose sole Design is to make* Experiments, *and Relate them. For such was our first Proposal, and the Intent of that great Personage, who with his Particular Protection, and far-reaching Judgment, caused us to take that Method; to which Sage, and Prudent Advice we have still punctually, and regularly conformed.*

THE CONTENTS.

Tab. 1. p. 1.



THE

DESCRIPTIONS

OF SOME

Instruments

To discover the Alterations of the *AIR*,

Caused by

HEAT and *COLD*.

IT is most usefull, and indeed a necessary thing in the making of Natural Experiments, to be truly informed of all the *Alterations* the *Air* is incident to; for since it receives into it self, and as it were, embraces all things, leaning on them with its whole weight from a vast height, they must needs all bend under this Pressure; and as this violence which they suffer, is more or less, so are they more imprisoned or enlarged. Thus the *Mercurial* Standard either rises or falls, at the different height of the *Atmosphere*, or as some think, correspondent to the various Temperaments which the *Air* receives from the Sun, or from the Shade, from the Heat, or from the Cold, when open, and free, or when shaded and oppress't with Clouds, when it either rarifies, or condenses it self, and so gravitates more or less upon the Stagnant *Mercury*, by which, with different Pressures, it forces it higher or lower into the immersed Cane. It is there-

fore requiſite (as well for that Experiment which we ſhall amply Treat of in the firſt place, as for others, which in the ſequel of this Diſcourſe we ſhall handle) to be provided with ſuch Inſtruments that we may be able to aſſure our ſelves, what is the true Meaſure, not only of the greateſt changes of the *Air*; but if it be poſſible, the niceties of the ſmalleſt variation. We will therefore in the firſt place, deſcribe thoſe which have been ſerviceable to us, though they may have been already diſperſed hence to ſeveral parts of *Europe*, ſo that they will want the pleaſing dreſs of Novelty to recommend them: nevertheleſs, they will not be unacceptable to thoſe that deſire a more nice and particular Information (if not of their uſe, which is eaſily comprehended, yet) of the way and Artifice of making them.

The Firſt Inſtrument

To meaſure the degrees of Heat and Cold in the Air.

Tab. 1. *Fig.* 1. LEt the Firſt Inſtrument be that repreſented by *Fig.* 1. which may ſerve, (as likewiſe ſeveral others) to ſhew the changes of the *Air*, in reference to *Heat* and *Cold*, and is commonly call'd a *Thermometer*: 'tis made of Criſtal-glaſs, after this manner. The *Artificer* by blowing with his own Mouth (inſtead of Bellows) through a Glaſs-Pipe upon the flame of a Lamp, forces it in one continued Stream, or ſeveral, at pleaſure, from one place to another, where it is requiſite; and by this means, ſhapes moſt curious, and admirable Works of Glaſs. Such an *Artificer* we call a *Lamp-blower*. Let him then make the Ball of this Inſtrument of ſuch a Capacity, and joyn thereto a Cane of ſuch a bore, that by filling it to a certain mark in the Neck with Spirit of Wine, the ſimple cold of Snow or Ice *Externally Applyed*, may not be able to condenſe it below the

the 20 *deg.* of the Cane; nor on the contrary, the greateſt vigour of the Sun's Rays at *Midſummer*, to Rarifie it above 80 *deg.* which Inſtrument may be thus fill'd, *viz.* by heating the Ball very hot, and ſuddenly plunging the open end of the Cane in the Spirit of Wine, which will gradually mount up, being ſuck'd in as the Veſſel Cools. But becauſe 'tis hard, if not altogether impoſſible to evacuate the Ball of all the *Air* by Rarefaction; and the Ball will want ſo much of being fill'd as there was *Air* left in it; we may thus quite fill it with a Glaſs Funnel, having a very ſlender ſhank, which may eaſily be made when the Glaſs is red hot, and ready to run; for then it may be drawn into exceeding ſmall hollow Threads, as is well known to thoſe that work in Glaſs. Put the ſmall ſhank of this Funnel into the Cane to be fill'd, and by forcing the Spirit of Wine through the Funnel with ones Breath, or ſucking it back again when there is too much; you may fill the *Inſtrument* up to what mark in the Neck you pleaſe. The next thing is to divide the Neck of the *Inſtrument* or *Tube* into Degrees exactly; therefore firſt, divide the whole *Tube* into Ten equal Parts with Compaſſes, marking each of them with a knob of white *Enamel*, and you may mark the intermediate Diviſions with green Glaſs, or black *Enamel:* theſe leſſer Diviſions are beſt made by the Eye, which Practice will render eaſie. This done, and with the proof of *Sun* and *Ice*, the proportion of the Spirit of Wine found; the Mouth of the *Tube* muſt be cloſed with *Hermes* :al at the flame of a Lamp, and the *Thermometer* is finiſh'd.

Smalto Bianco. *Smalto Nero.*

We rather make uſe of *Spirits*, than ſimple Spring Water for theſe *Inſtruments*; becauſe, firſt 'tis colder, (*i.e.*) ſooner ſenſible of the leaſt change of Heat and Cold, and by reaſon of its extream lightneſs, it more readily contracts it ſelf, quickly falling or riſing. Secondly, Simple Water, how pure and clear ſoever, yet in a little time lets fall ſome Sediment, or Dregs, which ſticking to the ſides of the Veſſel, at laſt clouds its Tranſparency: whereas the higheſt rectified Spirit of Wine, or the like burning Spirits, always keep Pellucid,

nor ever abate of their first Beauty. And since it is so *clear* and *Cristaline*, that at first view 'tis hard to discern the bounds between it, and the void space of the Neck of the Vessel; we sometimes used to tinge it with the Infusion of *Kermes*, or *Sanguis Draconis*; But when we observed, that how light and Refined soever the Tincture was, yet in time something still adhered to the sides of the Glass, and augmented rather then lessened the Difficulty, we at last wholly omitted the use of coloured Liquors; the other being discernable with a little straining the Eyes. We might here add many other Works and Curiosities touching *Lamp-working*; but as 'tis very difficult to Design, and draw things of this Nature upon Paper; so 'tis altogether impossible to make them intelligible in Writing: wherefore our *Operator* ought to be pretty well instructed before, and his Art will improve with frequent Practice.

The Second Instrument,

For the same use.

Tab. 1. *Fig.* 2. THis is but a *Copie* of the former, in little; there being no other difference between them, but in the length of the Stages the liquor has to run: *that* being double the length of *this*; *that* being divided into 100 *deg.* *this* but 50. *that* at the greatest Cold of our *Winter* subsiding to 17 or 16 *deg.* *this* usually to 12, or 11; and at a great extremity of Cold one year, to 8 *deg.* and *this* to 6 *deg.* And on the contrary, the *first* being exposed to the greatest Rage and Heat of the Midday *Sun* in our Climate, does not rise above 80 *deg.* When the *Second* at the same time exceeds little, or not at all 40 *deg.* The Rule of making these, so as they shall keep such a correspondence, is onely obtained by *Practice*, teaching how to proportionate the Ball to the Cane, and

and so to adjust the Quantity of Liquor, as they shall not vary in their Motions.

The Third Thermometer.

THe Third is also a *Copie* of the First, but much larger, whence it is more sensible, and swifter near four times; its length is 300 *deg.* made like the other Two, but as was said before we can lay down no certain Rule to make it Practice, and often Trials being the onely way to effect it, by increasing, and diminishing the size of the Ball, or the bore of the Cane, or the quality of the Liquor, till at length it hits right: And a famous Man in this Art, who served the most Serene *Grand Duke*, us'd to say, He could make Two or Three, or as many as you desired, of 50 *deg.* which being encompassed with the same Ambient, should all agree: but that the case was otherwise in those of 100. *deg.* especially of 300 *deg.* the smallest Inequality and Error committed, in making one with a large Ball, and small Neck, being very easie to be discovered: so that they will shew great Disagreement and inequality when compared together.

The Fourth Thermometer.

THis Fourth Instrument has a *Spiral Canale*, yet differs not much from the former; indeed it comes not near the same Scale of Proportion, it being impossible to draw so very long a Neck equal, and of the same size and bore throughout the whole length; because there is a necessity to pass and repass it often over the flame to bend it; whence it cannot be avoided when the Metal is softned by the flame, but the Cane *Tab.* 1. *Fig.* 3.

Cane will be ſtraitned and contracted in ſome places, and in others relaxed and ſwelled.

Blow then a Globe of a great Capacity, with a very long ſlender Neck, and Coyl it round as in the *Fig.* each *turn* being cloſe to the other, and riſing but with a ſmall *Angle*, that the whole Height may be as little as poſſible, and ſo leſs ſubject to be broken to pieces; then let it have at the top another leſs Ball hollow, and ſealed at the Flame, to be a receptacle for the Air in the Cane to retreat to, from the preſſure of the Water in raiſing it ſelf, leſt for want of room, and being every way cloſed, it reſiſts the aſcent of the Water, and ſo crack the Veſſel; after this manner may be had a very tickliſh *Thermometer*: and *as I may ſay*, of ſo exquiſite a ſenſe, that the leaſt flame of a Candle, in an inſtant ſhall be able to make the contained Spirit of Wine move ſwiftly: which Effect will be ſo much more conſpicuous, as the Ball is larger, which may be made very Capacious at pleaſure, without being tied to any Rule: This Inſtrument being made rather for *fancy* and *curioſity* to ſee the Liquor run the Decimals of Degrees by the onely impulſe of a warm breath, *&c.* than for any accurate Deduction, or Infallible Proportion of *Heat*, and *Cold* to be learnt thereby.

The Fifth Thermometer.

Tab. 1. *Fig.* 4. THis is more ſlow and lazy than any of the former, which immediately anſwer to the leaſt change of the *Air*; but this is not ſo nice to move upon a ſmall alteration; yet ſince 'tis made uſe of in divers Parts of *Italy*, and other places, we will not omit to ſay ſomething briefly of its make.

To make it, you muſt fill a glaſs Veſſel with Rectifyed Spirits of Wine, and immerſing a *Thermometer* of 100 *deg.* therein, place it in Snow or Ice to cool it; you muſt alſo put

put into the ſame Liquor many little glaſs *bubbles* blown, and *Hermetically* Sealed at a Lamp; theſe by reaſon of the *Air* contained in them, will keep themſelves floating upon the Surface of the Water; and if by chance any one being a little heavier in *Specie* than Water, ſhall ſink to the bottom; take it out, and upon a plate of Lead, with fine *Emeril* grind off ſo much of the end as will make it light enough to ſwim. Then the Veſſel being taken out of the Ice, carry it into a *Room* where the *Air* is well *heated* by a Fire, that the Liquor which before was very cold, may receive equally on all ſides the temperament of Heat. So by little and little, as the Liquor grows warmer, and by Rarefaction lighter, the Balls (which at a more intenſe degree of Cold kept juſt upon the Surface) ſhall begin to dive toward the bottom, and at the ſame time the Spirit of Wine in the *Thermometer* ſhall creep up. That Bubble or Ball thereof which ſinks when the *Thermometer* is at 20 *deg.* ſhall be reckon'd the *firſt*, that is, the heavieſt, becauſe it deſcended when the Water was yet very cold, and little, or not at all altered. That which ſinks when the *Thermometer* is at 30. *deg.* may be accounted the *Second*, at 40°. the *Third*, at 50°. the *Fourth*, at 60°. the *Fifth*, at 70°. the *Sixth*, and Laſt, or Lighteſt; whence it appears, that the Bubbles make a Scale of equal Differences; that is, from 10°. to 10 *deg.* as likewiſe, whence this Inſtrument is more *groſs* then the reſt, in that it ſhews by the riſing and falling of the Bubbles, the alteration of the *Air*; but to every 10*th.* *Degree* of that *Thermometer* which is divided into 100°. and to about every 4*th.* or 5*th.* of that of 50 *deg.* and to every 40°. of that of 300°. Let theſe Bubbles ſo tryed and choſen (And it would do well, if they were of *coloured Glaſs*, to be the more diſcernable in the midſt of the Liquor) be incloſed in a large Cane of Glaſs fill'd with Spirit of Wine, but not quite to the top, leaving ſome ſpace for the Liquor to rarefie, when the heat of the Seaſon ſhall require it; and then ſeal it *Hermetically*. If the heat of the Room is not ſufficient to make the *Thermometer* riſe to 60, it may be helped,

helped, by putting the Veſſel in a Bath of *warm water*, increaſing the heat by gradual pouring in *boiling Water*, if needful; and ſo the Spirit of Wine contained therein will not be more heated in one part than another, but take its temperature as gently and equally as poſſible.

The Deſcription of an Inſtrument *to diſcover the difference of Moiſture in the* Air.

HAving already treated of thoſe *Inſtruments* which ſerve to ſhew the Alterations happening to the *Air* from *Heat* and *Cold*; we come next to Deſcribe another, uſeful to diſcover the Changes which the *Air* is ſubject to purely from *Humidity:* and though there may be many and different *Inſtruments* of this Nature, which have been Invented by ſeveral Ingenious Perſons yet we will deſcribe this one: Of which (ſince it had its being firſt in this Court) we will ſay ſomething out of gratitude concerning its Invention and Uſe, though perchance it is wrote of by others.

It is part of a *Cone* of Cork *hollow* within, and *pitched*; and covered on the outſide over with *Tin:* at the ſmaller end it is inſerted into a Veſſel of Glaſs with a *Conical* Point
Tab. 1. ſhaped as in the Figure, and cloſed *Hermetically*: The Veſſel
Fig. 5. being ſo made, and placed upon its *Pedeſtal*, is to be filled with Snow, or ſmall beaten Ice; the water whereof as it melts, ſhall have its iſſue by the Pipe made in the upper part of the Glaſs. The *Uſe* of it is this, The ſubtil *Moiſture* carryed about by the *Air*, adheres by little and little to the ſides of the Veſſel, covering it at firſt but with a *dew* or *miſt*, till by the coming of more *moiſture*, it gathers into great drops, and at laſt ſtealing down the ſides of the *Conical* Glaſs drops into a tall Cup in the ſhape of a *Mumglaſs* divided into equal *deg.* and made on purpoſe to receive it. 'Tis evident, as the *Air* is more, or leſs full of moiſt Va-

pour,

pours, the force of the Cold condenſes a greater or leſs quantity of Water, meaſured by the graduated glaſs *Cilinder*. Wherefore deſiring to compare one *Air* with another; Obſerve in the *firſt Air* you would make uſe of, to what Degree the *Cilindrical* Glaſs is filled in a determinate *ſpace* of time, and then throw away the Water, and carry the Veſſel to the other place, and mark to what Degree the condenſed Water then riſes in the *ſame* time: and ſo the difference between the *moiſture* condenſed into Water at theſe two Experiments being found, gives the true difference between the *Humidity* of the two *Airs* propoſed to be compared.

We may likewiſe by expoſing this ſame Inſtrument in the *Air* when the *Wind* blows, find which is the *moiſter*, and which the *dryer*. So we have obſerved, that when our *South* Winds prevail, the Glaſs ſweats exceſſively, for the *Air* is then very damp, it may be from the *South* Sea, where probably the *Suns* Influence being great, Exhales thoſe moiſt Particles which afterwards incorporate themſelves with the *Winds*; and in a ſtrong *South-Weſt* Wind, it happened, that from 35, to 50 Drops have fallen in a Minute of an Hour. One time, the *North* and *South-Weſt* Wind ſtriving together, the Weather being very thick, ſo that the Clouds encompaſſed the Hills, we told 84 Drops in the ſame time: but at laſt, the *North* Wind getting the better, it gradually gave over ſweating, and in little more than half an hour the Glaſs was dry, though there was ſtill a great deal of Snow within it: and ſo it continued all that Night, and the next Day, while the ſame Winds kept abroad. Likewiſe when the *Weſt* Winds blow, the Glaſs is obſerved to be very dry. Indeed, no certain Rule can be given of theſe things, ſince they may be altered by ſo many Accidents, not onely from the *ſeaſon* of the Year, and *temperament* of the *Air*, but from the Nature of the Soils and Countries themſelves, which ſometimes alter the *Criteria* of theſe Winds. And we know in ſome *Cities* and *Places* the *South* Winds are colder than with us, becauſe perchance they may be bounded *Southward* with Mountains of *Snow*, the winds paſſing over which, are chill'd.

Libecciam Aquilonari & Libecci.

Ponenti.

Nevertheleſs, our *Inſtrument* remains ſtill unalterably juſt to every place where 'tis made uſe of, correſponding in all reſpects exactly enough to the ordinary *Indications* of Nature upon theſe Winds.

The Deſcription of ſome Inſtruments *to Meaſure* Time.

WE need not go far to ſeek an Experiment, requiring a true and exact *meaſure* of *Time*, ſuch as that by *Swings*, and *Sounds*, or *Stroaks*; ſince the foregoing Experiment is a ſufficient inſtance, where a Compariſon is made of the *Humidity* of *Air*, and *Winds*, to find the *Difference* and *Proportion* of Moiſture which in equal Spaces of *Time* diſtills from divers *Airs*, by means of a Glaſs Veſſel fill'd with Ice: Which Difference conſiſts ſometimes in ſo ſmall, and ſcarce perceivable *Minutie*, that the Juſtneſs of the moſt Acurate *Clocks* cannot diſcover it, becauſe we either count the time from *Stroke to Stroke*, and the *Ears* may poſſibly be deceived; or we take it from the Spaces ſhewn by the Hand, and then much more eaſily may the *Eyes* commit an Error; we muſt therefore of neceſſity have recourſe to an *Inſtrument*, that may be a more exact *Time meter*, than the *ſound* of four Strokes of the *Clock*, or the Minutes ſhewn by the *Hand* can be, in which the Judgment of the Senſes is ſo ſubject to miſtake. For (to paſs by the Errors that may be committed in the dividing of a *Clock*, or other material *Inſtruments*) it is very difficult to diſtinguiſh, whether the *Hand* is juſt upon the Point marked, or not. And then of *Sounds*, we muſt when all is done conclude, That the *time* is already paſt, before the *Clock* has done ſtriking.

Wherefore, we take the *Pendulum* or *Puppet*, to be the moſt exact Inſtrument; the *Swing* and *Return* of which, being taken for one *Vibration*, we never knew that in the Number

Number of many *Vibrations* one failure has happened, (a thing which ſeldom ſucceeds ſo well in *Practiſe*) nor the leaſt Variation able to cauſe an Error worth the Regulating; but becauſe the uſual *Pendulum* hanging by a ſingle Thread in that free Liberty of ſwinging (whatever is the reaſon thereof) in time deviates from its firſt *direction*, and towards the end when it approaches *Reſt*, its Motion is no longer in a *vertical Arch*, but in an *Oval Spiral*, in which we cannot diſtinguiſh, nor number the *Vibrations*; wherefore to keep the Motion true to the ſame *Path*, we hang the *Weight* in a double thread, faſtning each end thereof by it ſelf at a little diſtance to an Arm of *Metal*, as in the Figure. *G.* So the Ball or Weight being hung on this Thread by a ſmall Ring or Staple, moves in the Figure of an *Iſoſceles* Triangle; for ſince it hangs free upon the Thread, (though at the firſt impulſe of Motion the Figure may be rather a *Scalne*) yet by its weight, it ſlides down to the loweſt part to which it can fall, and keeps it ſelf fixt there: from this *Triangle* it comes, that the Motion of the *Pendulum* is regulated, while the Threads that make the legs of the *Triangle* (if we may uſe that ſimilitude) ſerve to ſtay the Ball from ſwerving more to one hand, than the other, and keep it always directly in the ſame *Path*. Since all Experiments wherein the *Pendulum* is made uſe of, require not the ſame diviſion of Time, a groſſer ſufficing for ſome, ſuch as is made by longer *vibrations*: and others again asking a Diviſion ſo nice, given by *vibrations* ſo quick one upon another, that the *Eye* can ſcarce diſtinguiſh them; to be able with expedition and facility to lengthen or ſhorten the *Triangle* without every time untying the Thread; let there be added below the *upper*, another arm of *Metal* alſo, filled with a ſquare hole on the upright piece of the *Inſtrument*, ſo that it may ſlip up and down upon it, and be fixt at any height by a *Screw* on the back: this arm is cut through the midſt, which ſlit being opened, and cloſed together by the means of Two other *Screws*, ſtops and holds faſt the Legs of the greater *Triangle* at any deſired *ſpace* between the Ball, and the upper arm,

the lower part remaining at liberty; while that part between the two Arms is immovable: by this means the leſſer *Triangle* below the ſtop at the ſlit which is its Baſe, *vibrates* freely, and ſo much the ſwifter as the Ball is ſuſpended ſhorter, and by conſequence the Legs of the *Triangle* more contracted.

To interpoſe here a word or two; *Experience* tells us, (as *Galileo* has already obſerved next the obſervation which he firſt made, of the very near equality of Swings, about the Year 1583.) that not all the *Vibrations* of the *Pendulum* fall preciſely in *equal ſpaces*, but as they approach nearer to *reſt*, ſo they diſpatch themſelves in *leſſer ſpaces of time* than at firſt, as may be ſhewn in its place. Wherefore in thoſe Experiments that require a greater acuracy, and ſo long a time of obſervation, that the little inequalities of theſe *Vibrations* in a great number of them may at laſt happen to be ſenſible, 'twas thought good to apply the *Pendulum* to the Movement of the *Clock*: a thing which *Galileo* firſt Invented, and his Son *Vincenzio Galilei* put in practice in 1649. So the *Pendulum* is moved by the force of the *Spring*, or *Weight*, and ſtill carryed to the ſame height each way, with this great benefit, that not onely the length of the *Vibrations* become exactly *equal*, but in a manner all the *Defects* in the other parts of the *Clock* are corrected and regulated. That we might be able to make uſe of ſuch an *Inſtrument* in ſeveral Experiments (which require the time, ſome more, ſome leſs ſubtilly divided) we made divers Balls of *Metal* faſtned to ſmall *Iron* Wires, of different lengths, each to be inſerted into the ſame *female Screw* when deſired: of theſe the ſhorteſt made its whole *Vibration*, in half a *Second* Minute of an Hour, the ſhorteſt needful; all other returns of ſhorter *Vibrations* being ſo ſwift, that the *Eye* is ſcarce able to follow them.

Let this ſuffice concerning thoſe *Inſtruments* of a more frequent uſe in the following *Experiments*.

Experiments

Experiments *appertaining to the natural Preſſure of the* Air.

THat famous Experiment of the *Quick-ſilver* is now ſpread throughout all *Europe*, which firſt in the Year 1643. offered it ſelf to the thoughts of the Ingenious *Torricelli*; nor is the noble and curious inference he makes therefrom leſs enquired after, and known, when he comes to contemplate the *cauſe* of that ſtrange *Effect*; for he propoſeth, that it is the *Air* preſſing upon all Bodies under it, forces them, and removes them out of their places, when ever there is a *void* and *empty ſpace* whereto they may retire, and betake themſelves; and particularly *fluids*, from their great tendency to *Motion*: whereas *ſolid* Bodies, as Gravel, and Sand, *&c.* or pieces of greater Stones (when there is an endeavour to move them) are rather joyned, and preſt together the cloſer by that means, from the roughneſs and irregularity of their parts, ſo locking the whole Maſs together, that they ſuſtain and prop up one another, and ſo reſiſt more powerfully any *force* applyed to move them: but on the contrary, *Liquid* Bodies, it may be from the ſmoothneſs or roundneſs of their Particles, or from ſome other *Figure* they are of, are eaſily moved, their parts ſtanding as it were in *æquilibrio* upon a Point, that as ſoon as ever they are preſſed, they yield every way, and ſpread themſelves, as we ſee *Water* from the leaſt *Body* that falls thereon, breaks away on all ſides in orderly *Circles*: and who knows, that from this incoherence and looſneſs of the parts, it may not happen that 'tis ſeldom or never ſtable, though in its moſt *proper receptacles*, where it ſeems ſometimes Stagnant ſo that the ſmalleſt breath of Wind curls and agitates it; and even in ſtanding Lakes and Pools, where it ſeems moſt Sedate, though the Eye perceives it not, yet there the *Water* is in perpetual

Motion,

Motion, and obedient to all the *undulations* of the *Air*, which it may be is never at *Reſt*; nor is this more peculiar to *Water* than any other *Liquid*; in all which, as ſome think, the force of the *Airs Preſſure* is very evident; eſpecially, when they are in a place which in any one part of its *Superficies* has a *Vacuum*, or as it were void ſpace into which the *Liquid* may retire: for the Contiguous Air preſſing the Fluid on the one part with ſo many Miles height, when on the other part (contiguous to the *Vacuity*) it touches not, nor can gravitate at all; it muſt neceſſarily mount it into that void ſpace, till the raiſed fluid becomes an *Equipoize* to the *Airs Preſſure* on the other part. This *Equilibrium* with divers *Fluids*, is at divers Heights, as they are more or leſs heavy in *Specie*; a leſſer or greater quantity of which is able to reſiſt the Force and Weight of the *Air*. We (following the common Practice, as likewiſe the firſt Inventer *Torricelli*) make uſe of *Quick-ſilver*, which being very heavy, is much more commodious for the Experiment, making a *Vacuum* in a far leſs ſpace than any other *Liquid* can. What is needful to be ſeen in this Matter, the following Experiments will manifeſt.

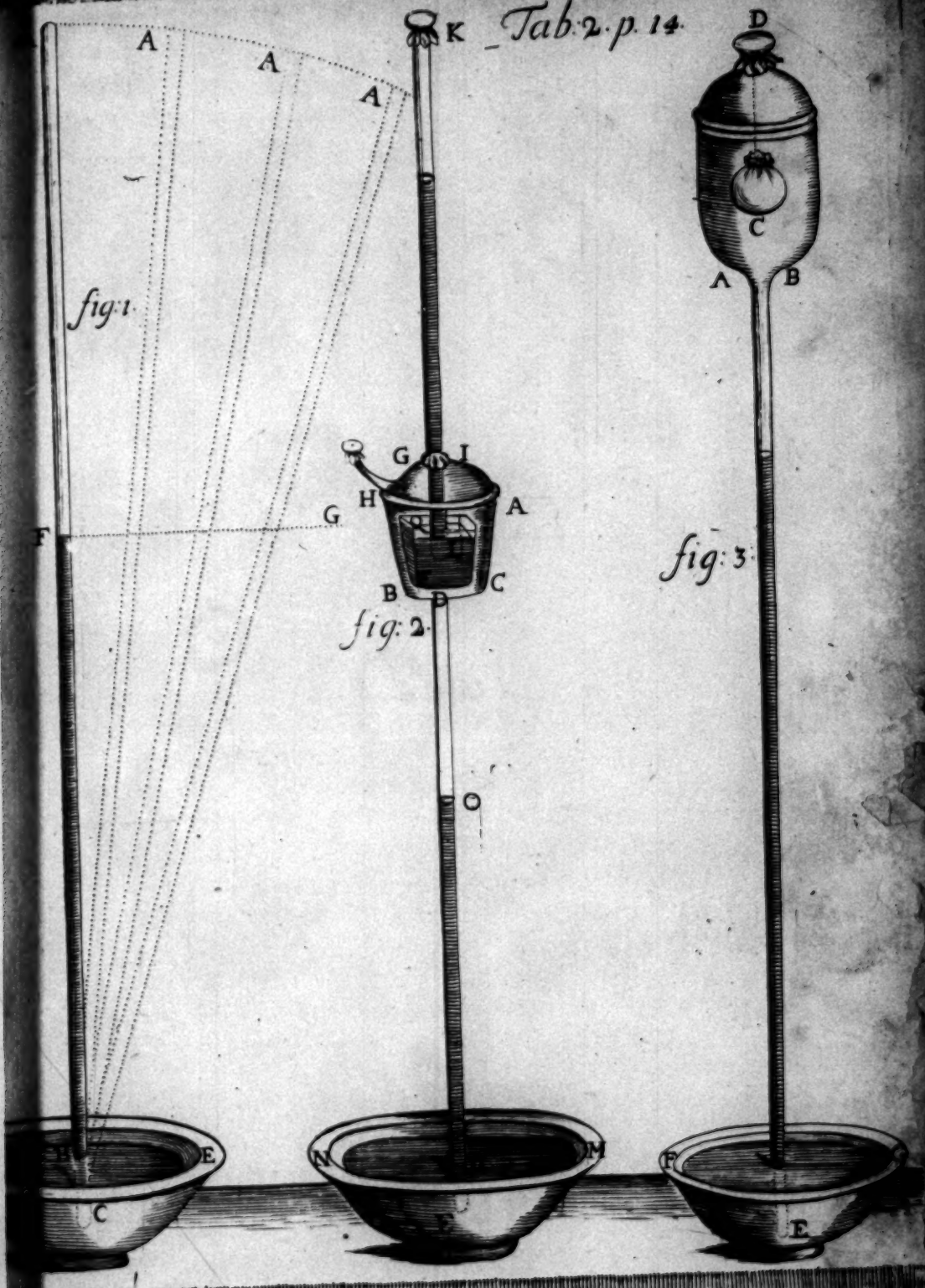
An Experiment,

Suggeſting to Torricelli *the firſt* Inventor *thereof, that it might be the natural external* Preſſure of the Air *which ſuſtains the* Mercury, *or any other* Fluid, *at a determinate Height in the* empty *ſpace of a Cane*, &c.

2 *Bracciv. Tab.* 2. *Fig.* 1.

PRovide a glaſs Cane about 46 Inches long, *Hermetically* ſealed at one end, and open at the other, repreſented by A B C. fill this with *Mercury*, and ſtop the mouth C. cloſe,

Tab. 2. p. 14.



cloſe, either with your Finger, or a moiſtned Bladder tyed over it; invert it, and gently immerſe it into the Veſſel of Stagnant Quick-ſilver D E. then untie the mouth C. and immediately the *Mercury* in the Cane will ſubſide for the whole ſpace A F. where meeting with its Level, or Counterpoiſe after ſome Fluctuations, it reſts immovable: and the Cilinder of Quick-ſilver ſuſtained E: B. which bears upon the Superficies of the Stagnant *Mercury* D E. ſhall be about the length of 28 $\frac{6}{15}$ Inches, which length is found unto vary, though but little, from External Accidents of *Heat* and *Cold*; and ſomething more from the divers ſeaſons of the *Air*, as appears plainly from a long Series of our Obſervations. Nevertheleſs, theſe variations being very little, it will be always about the before-mentioned Height of 28 $\frac{6}{15}$ Inches, or near it. *Bracc* $\frac{1}{2}$

The ſpace A F ſhall contain no *Air*, which is manifeſt by inclining the Cane about the Point C as a *Center*, when you will find the internal Level F ſucceſſively move towards A, but never riſe above the *horiſontal* prickt line F G, drawn from the point F, the firſt height of the *Quick-ſilver*, when the Cane was *perpendicular*; and if the end A be inclined quite to the line F G, the Cane will be full of *Quick-ſilver*, except a very little at A, whither ſtill above the level of the included *Mercury*, gathers together either ſome *air* wherewith perhaps it is impregnated, or ſome other inviſible *effluvia* exhaling there from. This is moſt conſpicuous, when a ſmall quantity of Water is in the Cane, which in making the *Vacuum* gets above the *Mercury*, and diſcovers in their Paſſage through the midſt of it, that ſeveral ſmall Bubbles riſe out of the *Mercury* towards the empty ſpace; as may be ſhewn hereafter.

This Vacuity of *Air* may likewiſe be proved by *Water* poured upon the *Quick-ſilver* in the Veſſel D E. for lifting the Mouth of the Cane C out of the *Quick-ſilver*, as ſoon as it is every way encompaſſed with the *Water*, the *Mercury* will fall down, raiſing the *Water* in its place to the top of the Cane; provided it exceeds not the length of 33 Feet 17 *Bra.* $\frac{3}{5}$

25 Inches, to which (as may be elſewhere diſcourſed) it is uſual for *Water* to be ſuſtained; probably from the ſame power that bears up the *Mercury* to 28 $\frac{1}{2}$ Inches; and indeed, there will be no great quantity of *Air* at the top of the Cane; ſince there is onely ſome thin *Effluvia* forced into an almoſt inviſible ſpace, which (as we ſaid) riſe from the *Quick-ſilver*, or is ſome other ſubtil Matter capable of penetrating thither.

Upon this ground we ſhall call (as before for brevity-ſake) the ſpace A F, (and any other left by the ſubſiding *Mercury* in a like Veſſel) the *vacuum*, or *void ſpace*, (*i. e.*) empty, and void of *Air*; at leaſt ſuch as unaltered, and in its Natural State encompaſſes the Cane; not preſuming here to exclude *Fire*, *Light*, or the *Ether*, or any other very thin Bodies, which are either in part diſperſed with little *vacuities* interpoſed, or wholly fill'd the ſpace, which we call the *vacuum*, being ſtretcht and attenuated as ſome think. Nevertheleſs, 'tis our intent in this place, onely to diſcourſe of the Space fill'd with *Mercury*, and endeavour to find the true cauſe of that wonderful Counterpoiſe of this Weight, without entering into any Diſpute with the deniers of a *Vacuity*. And ſince many Experiments have been made for this end, (as well what is related by others, as what has been invented by our *Academy*) the ſucceſs ſhall be faithfully ſet down; our Cuſtome being always to deliver the Matter *Hiſtorically*, and not to defraud the *Inventors* either of their *Invention*, or due *praiſe*.

An

An Experiment

Of Mr. Robervals *in favour of the* Airs Preſſure *upon Inferior Bodies, tryed in our* Academy.

LEt there be a glaſs Veſſel A, to the bottom of which B C, perforated at D; let the Cane D E 46 Inches long be affixt, over this hole ſet the ſquare glaſs F, then cloſe the Veſſel A with the glaſs Cover G H, having an open noſe H I, and a hole at G, through which let the Cane K I be put open at each end, and about 46 Inches long, or not leſs then 30; let this down into the Glaſs F, but not quite to touch the bottom; and faſten it there with Maſtic, or other Cement at the fire, to the hole in the Cover G; this Cement, or Paſte, is made of Brick reduced to an impalpable Powder, and incorporated with Turpentine, and Greek Pitch; 'tis admirable to ſtop Glaſſes to exclude the *Air*; let it be luted cloſe with the ſame, round about where the ſaid Cover and Veſſel joyn; and cover the lower mouth E with a Bladder: Then pour in at the upper end K ſo much *Mercury*, till running over the Glaſs F it falls upon the bottom B C, and thence by the hole D fills the lower Cane E D, and after that the whole Veſſel A, the *Air* having its way out by the open Noſe H I, which when the *Mercury* begins to run through it, cloſe well with the Bladder I, and lift up the whole Cane to K till a little runs over, that not the leaſt *Air* may remain when cloſed, which do with the Bladder K. Laſtly, open the other Bladder at the Mouth E under the Superficies of the Stagnant *Mercury* M N, into which the Cane is immerſed, and immediately the upper Cane K L, and the Veſſel A will empty themſelves; the Glaſs F and O P, part of the Cane D E being about 28½ Inches above the Level, M N remaining full. This done, the ingreſs of

Tab. 2. *Fig.* 2. 2 *Brac.* 2 *Brac.* *Brac.* ⅓.

the External *Air* upon opening, or pricking the Bladder I, will immediately ſuppreſs the *Cilinder* of *Mercury* O P into the lower Veſſel, and raiſe up another Q R from the *Mercury* in the glaſs Cup F into the Cane L K equal to the former O P, and therefore 28½ Inches long; and this *Cilinder* will not ſubſide until the External *Air* entring at the top K, ruſhes in upon it through the Cane L K.

1 *Brac.* ½

If in this Veſſel A, a little Bladder be encloſed, taken carefully out of a *Fiſh*, the *Air* that is Naturally therein being firſt expreſſed, ſo as very little be left in the folds thereof, and then the Orifice well tyed together, as ſoon as ever (by the ſubſiding of the *Mercury*) the Bladder ſhall be in *vacuo*, that little *Air* remaining in it will ſwell, and diſtend it; nor will it ſhrink again, till by opening the Veſſel at K the External *Air* gets in to preſs upon it.

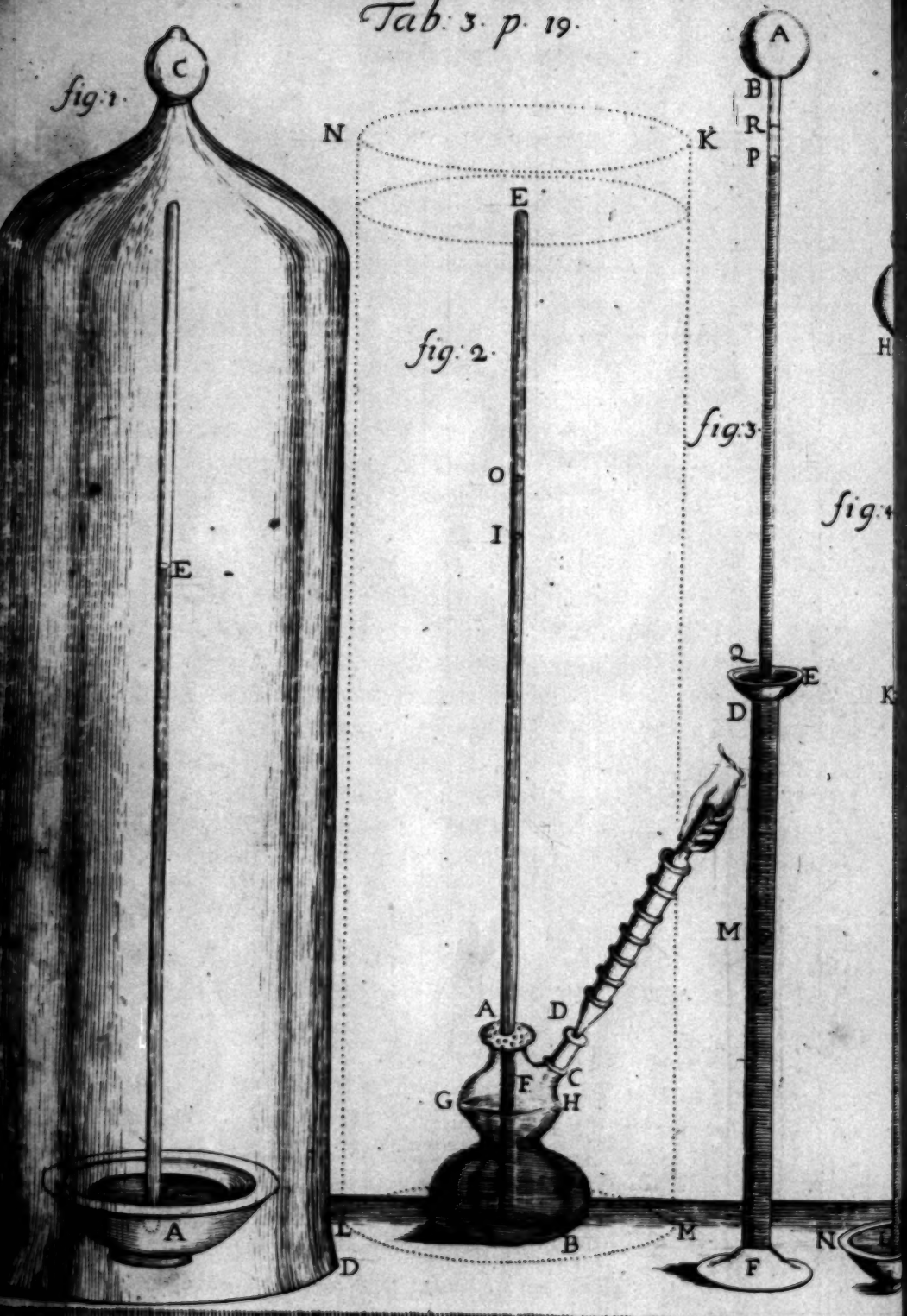
But we have obſerved more clearly the like Expanſion of *Air in vacuo*, in a Veſſel made after another manner, as A D B, wherein a Lambs Bladder ſqueezed together, and almoſt wholly diſcharged of *Air*, is incloſed thus; fill the Veſſel with *Quick-ſilver* by the mouth D, and tye it over with a Bladder, the lower Mouth E being before ſtopt with the Finger, then immerſing it into the *Quick-ſilver*, in the Veſſel F G, open the Mouth E, and let the *Quick ſilver* ſubſide; then will the Bladder C hung by a Thread in the empty Veſſel A D B ſwell it ſelf, and ſo continue, till by opening the Mouth D, the External *Air* enters at the Top, which at the ſame time will bear down the *Cilinder* of *Mercury* into the Veſſel at the bottom F G, and preſs together the Bladder.

Tab. 2. *Fig.* 3.

Likewiſe, if in cloſing the Mouth D, there be put upon the *Mercury* a little *froth* made with *whites* of *Eggs*, or *Soap-ſuds*, ſtill as the Veſſel A D B empties it ſelf, the *Air* impriſoned in theſe ſmall *bubbles* will ſo ſwell them, that at length breaking through its thin Confinements, it ſhall be at liberty, and quite releaſed from the Liquor, which will fall down upon the *Mercury* like Dew ſeparated from that fine ſteame of *Air* contained in the *froth*.

Experiments

Tab. 3. p. 19.



Experiments

Alledged by ſome againſt the Preſſure of the Air, *and the Anſwer thereto.*

THere have been Two Experiments, from which ſome of our *Academy* judged a conſiderable *Argument* might be raiſed againſt the *Preſſure of the Air* upon Inferior Bodies, and the Effect of ſuſtaining Fluids attributed to ſomething elſe.

One was, by covering the Veſſel A, and likewiſe the Cane with a great *Bell* of Glaſs B C D paſted down cloſe to a Table round the edges: for then they imagine, that if it were true, that the weight of the whole Incumbent *Atmoſphere of Air* did protrude the *Mercury* into the Cane, and counterpoiſe it with its weight; by defending (with this Cover of Glaſs) the Stagnant *Mercury* from ſo great a *Preſſure*, the ſmall, and ſcarce ſenſible weight of the little portion of *Air* included within the *Bell*, muſt of neceſſity be unable to keep the *Quick-ſilver* at the ſame height whereto the *momentum* of ſo vaſt a ſpace of *Air* had raiſed it; but notwithſtanding this, they never obſerved it to ſubſide a jot from the uſual height E G. *Tab.* 3. *Fig.* 1.

The Second *Experiment* was of the ſame Nature, but more Artificial.

We fill'd with *Mercury* a ſmall Veſſel A B (which at firſt was made without the Beak C D, added afterwards for another Experiment) and plunged into it when full, the Cane E F, and making the uſual *Vacuum*, there was poured out from the Veſſel A B a ſmall quantity of *Quick ſilver*, ſo that a little *Air* might be in the ſpace A H to bear upon the *Stagnant* Level H G, and then the Weight and *Preſſure* *Tab.* 3. *Fig.* 2.

of the External *Air* was kept off, by closing carefully with the afore-named Cement, the round space A between the Neck of the Vessel, and the Cane; and yet in this case, when the bulk of the External *Air* was so lessened to nothing almost, we saw no sensible abatement of the *Mercurial Cilinder* I F below the usual height.

But the Assertors of the *Airs Pressure* answer these Experiments thus. That these Events on the contrary greatly favour their *Opinion*; for the immediate cause (as they say) that forces, and powerfully sustains the *Mercury*, to the height of 28½ Inches, is not the weight of the Incumbent *Air*; which indeed is taken off by the Bell in the *first* Experiment, and by the Cement in the *second*, but is in reality an effect of Compression, which was produced and wrought in the *Air* (contained in B C D *Fig.* 1. and in A H *Fig.* 2.) by that weight before they were Cemented close: whence 'tis no wonder, that the *Quick silver* subsides not from its usual height, the *Air* keeping in the same state of Compression as 'tis forced to do, from the resistance made by the glass Bell, and Cement, which supplies the place of all that vast Tract of Incumbent *Air*.

1 *Brac.* ½

And because 'tis yet believed by some, that the force of a supposed *Spring* in the *Air* acts wholly in this *Effect*, so as without it by no means it could happen; 'twas therefore attempted to insinuate the contrary, by the following Experiment.

Taking the same Vessel A B, with its Cane E F (before we poured off any of the *Mercury*, as was directed in the former Experiment, or stopt up the Mouth of the Vessel at A with Cement) and then setting all in a great Vessel full of *Water* K L M N, the *Quick-silver* was observed to be sensibly depresst from A to G H; and on the contrary, raised in the Cane from I to O; this Ascent being about the *fourteenth* part of the whole height of the *Water* E F: then the Mouth A was closed, that so onely the *Water* in the space A G H might press upon the *Mercury*, which nevertheless lost none of the height lately gained by the weight

of

of all the Incumbent *Water* E F, above the Firſt Level I; yet in this caſe the included *Water* A G H, not by vertue of any Springs (which perchance it had not) but becauſe it had been forced by the Charge of the whole height E F, into the ſpace left by the *Quick-ſilver* riſing from I to O, and kept there by the ſame force, and ſo hindred from Returning. The ſame may be ſaid to happen to the *Air.*

Laſtly, Some deſirous to ſee what Effect a greater, or leſſer Rarefaction of the *Air* included in A G H would have, made this Trial.

Joyning to the Veſſel A B the Beak C D (into which they faſtned a Mouth of Metal with a *female Screw*), they adapted a *Syringe*; Then whenever a *Suction* was made of the *Air* in A G H, and ſo what remained attenuated and weakned, the Level I, might be ſeen to *ſubſide*, contrarily when compreſſed more, by forcing in new *Air*; the ſame Level I *was raiſed.*

The ſame happens from *Fire* or *Ice* approaching it; for the Mouth C being cloſed, when *Fire* is Externally applyed to the *Air* in A G H, the *Mercury* riſes, and by the application of *Ice ſubſides*; as if after the ſame manner, as it happened in the contrary operations of the *Syringe*; the *Air* had been Condenſed, and enforced by Heat, and rarefied and weakned by Cold; from all which Matters it ſeemed probable, that this *ſuſtention* of the *Fluid* does not abſolutely depend upon the *weight* of the *Air*, but alſo upon the *compreſſion* which *lower* parts of the *Air* receive from thoſe *above.*

An

An Experiment

To know if the Air *near the* Superficies *of the Earth, is preſſed by the weight of the* Air *above, and if it be put in a void ſpace at its Liberty; whether it will expand it ſelf to a greater ſpace, and how much when yet it is ſtill unaltered by any new degree of Heat.*

THE Ingenious Obſervation made by *M. Roberval* with the little bladder of *Air* enlarging it ſelf in *Vacuo*, moved ſome to believe, it might be determined how far the *Air* is capable of *Expanſion* when at abſolute liberty in any place; for it ſeemed probable to them, that in any Veſſel propoſed, a *void* ſpace might be aſſigned ſufficient for the whole increaſe of ſuch a quantity of *Air*; whence whatever ſhould happen to exceed that *Quantity* (requiring a more ample ſpace to dilate it ſelf in) muſt proportionably more, or leſs depreſs the *Mercurial Cilinder* below the uſual height of about 28 Inches: and on the other ſide, what ever comes ſhort of it, will eaſily permit the *Mercury* to riſe to the uſual height. The Experiment is thus,

Tab. 3. *Fig.* 3. *2 Brac.* Let there be a Veſſel of Glaſs A B C, with a ſhank B C about 46 Inches long, open at C; and let there be a tall Glaſs provided, D E F fill'd with *Mercury* to immerſe the ſhank B C into, but ſuch a Veſſel as may not onely ſerve to immerſe it into, but capable when deſired of receiving either all, or a great part of the Shank into it ſelf as a Scabbard.

Tab. 3. *Fig.* 4. Let there be another Veſſel G H I equal in all reſpects, as near as may be to the former A B C, in which make the uſual *vacuum*, marking the height to which the *Mercury* is

is ſuſtained at that time, K L; then fill with *Mercury* the Veſſel A B C *Fig.* 3. being as was ſaid of the ſame ſize by the Mouth C up to M, and let M C remain fill'd with *Air*.

It is clear, that ſtopping with your Finger the Mouth C, and inverting the Veſſel, the ſmall quantity of *Air* left M C will paſs through the *Mercury*, and take its place in A. Then plunge the Mouth C beneath the Level of the Stagnant *Mercury* D F, and removing your Finger make the *vacuum* P A. The height of the *Mercurial* Standard will be P Q, meaſure it, and if it be found equal to L K in the Veſſel G H I *Fig.* 4. in which no *Air* was left to alter it, it ſhews that the *Cilinder* of *Quick-ſilver* P Q is not in the leaſt influenced by that little *Air* remaining M C, becauſe the *ſpace* left empty from A to P is more than ſufficient for its utmoſt *Expanſion*. Proceed then gradually to depreſs the Cane, or Shank B C into the *Mercury* D F, that the Level P may be gradually raiſed alſo, ſuppoſe to R, ſucceſſively leſſening the ſpace P B A left for the *Air*; continue this *depreſſion* as long as the Height Q R ſhall be found equal to K L. And Note that R is the fixt and utmoſt *bounds* of the whole height of a *Cilinder* of *Mercury* equal to K L, all the ſubſequent heights towards B (cauſed by a further *depreſſion* of the Cane into the Veſſel D E) being ſucceſſively diminiſhed: whence 'tis probable, that the void ſpace A B R is quite filled by the Expanded *Air*; becauſe from R upwards, the *Mercurial* Cilinder ſuffers ſome force from within: an evident ſign (as ſome think) that the Quantity of *Air* M C will not be contented with a leſs ſpace, than A B R for its full, and free *Expanſion*; the meaſure of this ſpace A B R, and by conſequence of the Expanſion of the *Air* M C, is thus obtained.

All things being as in the Veſſel A B C, where the *air* M C has its utmoſt Dilatation in the ſpace A R; then ſeek the proportion between the ſpace M C fill'd with *air* naturally *compreſt*, and the ſpace A R fill'd by the ſame *air dilated*, which is found at one trial by weighing the *water* that *Fig.* 3.

may

may be contained in the ſpace M C, and likwiſe that which may be contained in A R; as ſuppoſe they are found in Proportion to each other, as 1 to 174, we may affirm the ſame of the *air*, that (when at its greateſt *Expanſion* it takes up 173 times a larger ſpace, than when in the ſtate of its Natural *compreſſion*.

Note, that having often reiterated this Experiment, and at divers ſeaſons it has not always ſucceeded in the ſame proportion: for when at firſt we made it with another kind of *apparatus*, though the Operation was much the ſame, yet the *Proportion* was as 1 to 209. afterwards making uſe of the preſent *Inſtrument* we found it as 1 to 182; Laſtly, the third time (which alſo ſeemed to be more exactly performed than before) it was (as is ſet down) as 1 to 174; nor is this diverſity ſtrange, conſidering that the Experiment can never be made with the *ſame air*, but ſtill either more or leſs compreſt, as the Seaſon is *warmer* or *colder*, and as the place of Obſervation is higher or lower, whence 'tis impoſſible it ſhould be Dilated in the ſame manner, or in the ſame fixt and unaltered *Analogy*.

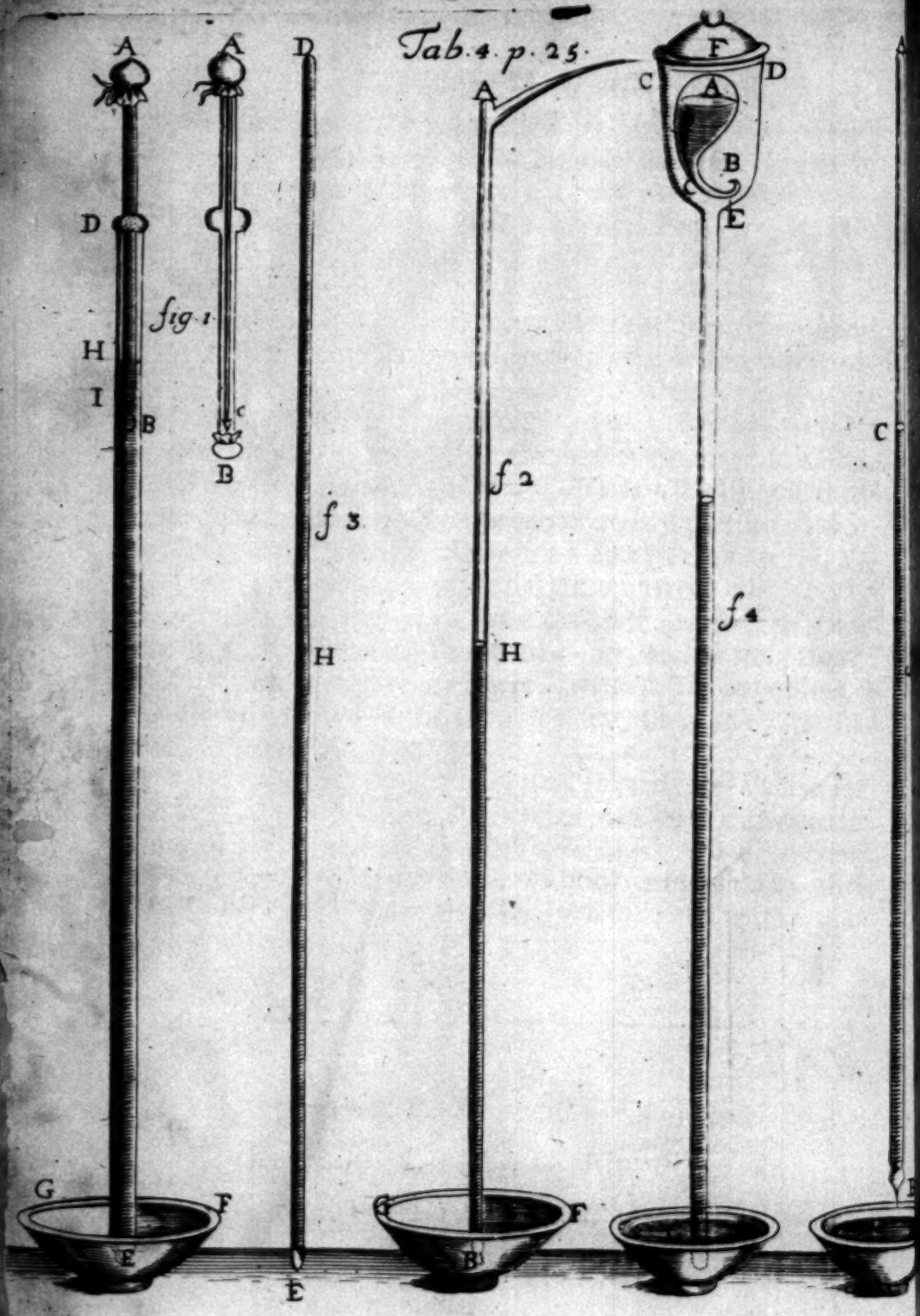
Fig. 4. Note alſo, that the Ball G H was joyned to the Cane H I, becauſe if any Inviſible Particles of *air* were diſſeminated through the *Mercury*, they might riſe into the Ball, and have room enough to expatiate in without being able by their *Preſſure* to alter the natural Height K L raiſed by the *equipondium* of the *Air*.

An Experiment,

Propoſed to ſhew, that where the Preſſure *of the* Air *is taken off, the* Mercury *is no longer ſuſtained.*

Tab. 4. *Fig.* 1. HAving choſen a ſmall Cane of Glaſs A B not ſo long as the *Mercurial* Standard, cloſe its lower mouth B with a *Bladder*,

Tab. 4. p. 25.



Bladder, fill it at A with *Mercury*, and put into it a little Dart C A, the one end gently touching the Bladder tyed at the bottom of the Cane, and the other a little above the Mouth A; which alſo cloſe with a *Bladder*.

Let there be another Cane D E, longer than 30 Inches, the *Mercurial* ſtandard, made ſo that the Mouth thereof E may be eaſily covered with the Finger, and the end D large enough to receive the Cane A B, which already fill'd with *Quick-ſilver* muſt be put therein, obſerving to let it down ſo low, that its end B may be leſs than 28$\frac{1}{2}$. Inches from the Superficies of the Stagnant *Mercury* F G, reckoning towards D; then faſten, and cloſe ſtop the two Canes together at D with Cement, that the *External Air* be perfectly Excluded. After this at E fill the whole Cane E D with *Mercury*, and ſtopping it at E with the Finger, invert it into the Stagnant *Mercury* F G, and make the *Vacuum* in the upper part D H, that the mouth B may ſtill remain immerſed in the *Quick ſilver* H I; cloſe again the Mouth E with your Finger, yet not raiſing it out of the *Mercury* F G; whence the Communication between the *Quick-ſilver* F G, and that in the Cane D E being hindred by the Finger, the Cane D E will be as a Veſſel, into which the little Cane A B is immerſed: then ſtriking the end of the little Dart A C, thruſt off the *Bladder* from the bottom B; as ſoon as 'tis opened, the *Mercury* will all run out of the Cane A B, (although 'tis ſhorter than the *Mercurial* Standard, and its Mouth B ſtill in the *Mercury* H I) contrary to what would have happened, if the ſpace D H now *void*, had been *full* of *air*: as the following Experiment will manifeſt. *Brac.* $\frac{1}{4}$

An Experiment

Likewiſe propoſed, to try if (when the Preſſure of the Air *is taken of) the ſuſtained Fluids will ſubſide, and upon its return be raiſed again.*

Tab. 4. *Fig.* 2. 2 *Brac.* LET the Cane A B be about 3 Foot 10 Inches long, and Hermetically ſealed at A; let the Beak A C be drawn ſo ſlender, that it may be eaſily nipt off with the Fingers, and with as little trouble ſealed again with the flame of a Candle: fill the Cane with *Quick ſilver* at the Mouth B, which (as alſo the Mouths of all Canes and Veſſels employed in making a *Vacuum*) ought to be ground, and rubb'd ſmooth; ſo to be more ſecurely ſtopt with a Finger. *Tab.* 4. *Fig.* 3. Then let there be another Cane D E made of the length of the firſt A B, and ſeal it at one end, but let it be open at the other, not with a round Mouth as the former, but cut a ſlope; this when fill'd with *Mercury*, is to be put like a Sword into its Scabbard into the Cane A B, made large enough to receive it. Then the Mouth B being ſtopt with the Finger, invert both the Canes, and plunge them into the *Mercury* in the Veſſel F G, making the *vacuum* as is uſual; which will be at the ſame height in both Canes, Levelling the *Mercury* in the innermoſt and outermoſt two at H; then with the Finger ſtop the Mouth B of the Exterior Cane, while 'tis yet beneath the Superficies of the *Mercury* F G; ſo that the *Mercurial* Cilinder B H may have no farther *Communication* with the *Mercury* in the Veſſel F G. But the Exterior Cane will be a Veſſel to contain the inner Cane D E, as in the former Experiment; and the Mouth of the inner Cane E, will by reaſon of its Oblique Figure, remain open:

this

this done, nip off the end of the Beak C, that the Air entering thereat upon the *Quick ſilver* H in the Exterior Cane, encompaſſing the other, and preſſing thereon, may immediately fill the innermoſt Cane D E; which it will do, provided that in the Cane A B there is enough *Quick-ſilver* to fill it; and the ſpace from A to H, which is the *vacuum*, exceeds not 30 Inches This Experiment is eaſily made, and repeated in a ſhort time. *Br.* ½

An Experiment,

Propoſed for the ſame end, to know if the Air *acts in the* ſuſtention *of Fluids.*

LEt there be a little glaſs Vial as A B C, whereof the Mouth C is drawn ſo ſmall, that being filled with any Liquor, and turned downward, though open at C, yet it will not run out; fill this with *Mercury* with a ſmall Glaſs funnel, and ſtop it at C with Wax, or Maſtick, then place it in the Glaſs Veſſel D E, ſo that the Mouth thereof C may reſt upon it, and the cover F be cloſed with the uſual Cement; then fill by the Mouth G, the whole Veſſel D E with *Mercury*, and make the *Vacuum*; which done, apply a Candle (on the outſide of the Veſſel D E) to the Mouth of the Vial C, and ſo melt off the Wax: as ſoon as ever 'tis open, the little Vial will begin to run, and empty it ſelf of the *Mercury*; but upon *admiſſion* of *air* into the Veſſel D E, it will immediately ſtop. *Tab.* 4. *Fig.* 4.

If inſtead of *Mercury* the Vial be filled with *Oile*, or *Wine*, or any other *Liquor*, the Effect will be the ſame.

An Experiment

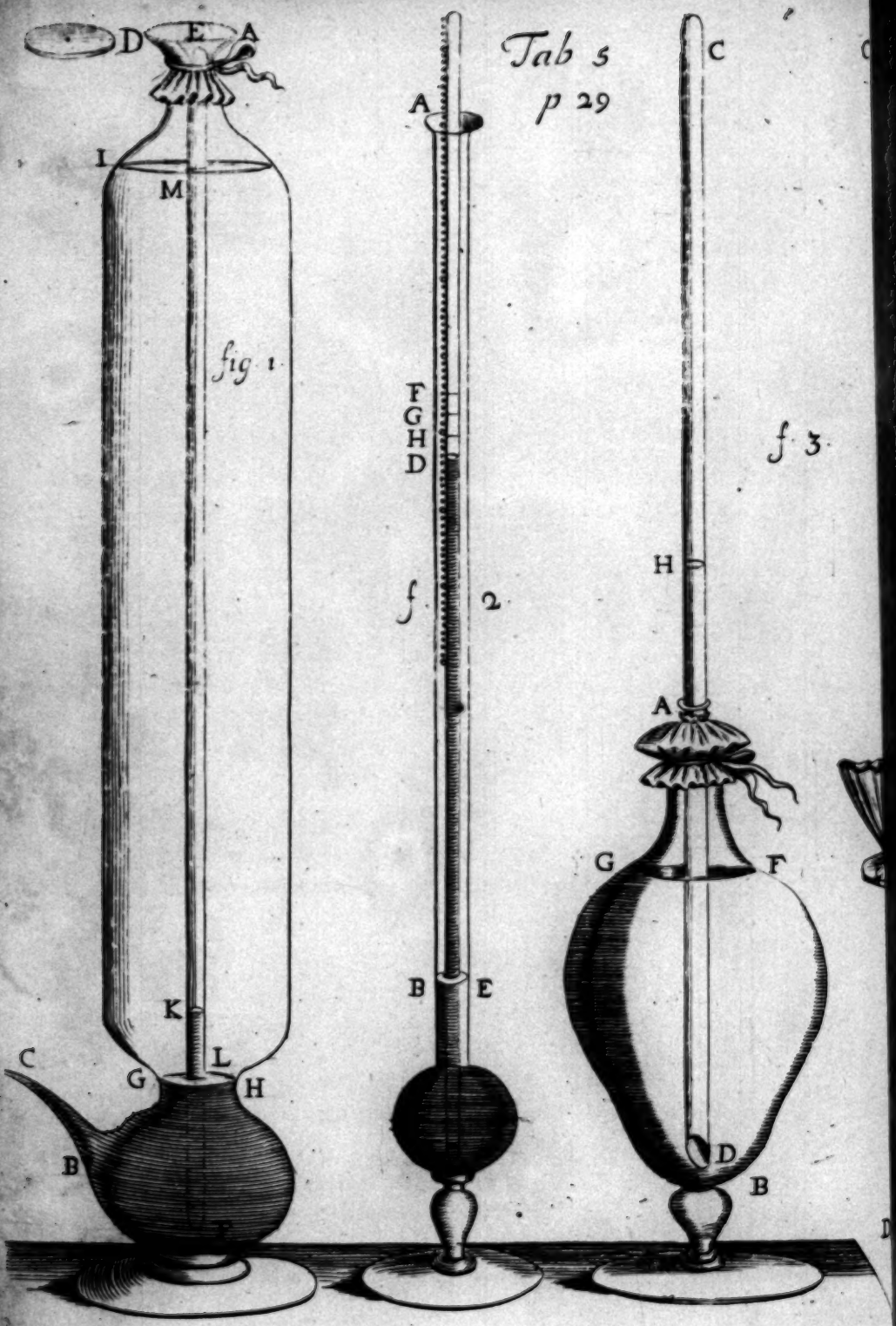
1 Brac. $\frac{1}{4}$ *To ſhew, that in any Veſſel above* 28 $\frac{7}{11}$ *Inches long, fill'd with* Mercury, *provided it has a very ſmall mouth, when it is inverted in the open* Air, *a* Vacuum *will be made in all that ſpace which is above the Height of* 28 $\frac{5}{11}$ *Inches.*

Tab. 4. Fig. 5. TAke a Glaſs Cane A B of what ſize and length you pleaſe, above 28 $\frac{6}{11}$ Inches, ſeal it at A, and let it be open at B, with a very ſmall Orifice; fill it with *Mercury*, and hang it in the open *Air* Perpendicular, with the end B downwards, the *Mercury* will preſently run out, (not by drops, but) in a continued ſtream till it ſubſide to C, the 1 Brac. $\frac{1}{4}$ uſual height of about 28 $\frac{6}{11}$ Inches, and then it will ſtop of it ſelf.

An Experiment

To ſhew more evidently, that where the Preſſure of the Air *is wanting, the bearing up of the Fluid is leſſened in a Cane of any length; and upon the return of the ſame Preſſure, raiſed up again.*

Tab. 5. Fig. 1. 2 di Brac. LEt there be a Veſſel of Glaſs A B, about 15 Inches long, with a Beak B C drawn very ſmall, and open at C; at the Mouth A D fill the whole Ball G F B with *Mercury*


Tab 5
p 29
D
E
A
I
M
fig 1
K
C
L
G
H
B
A
F G H D
f 2
B
E
C
f 3
H
A
G
F
D
B

Mercury gradatim, that as it riſes in the Ball, it may alſo in the Beak, driving out the *Air* it finds there before it; and when it comes up to C, ſeal it with a Flame. Then take a ſmall Cane E F ſealed at E, and cut tranſverſly at F; let it be a little ſhorter than the inward height of the Veſſel A B; this through the ſmallneſs of its bore, and being ſhorter than the *Mercurial* Standard, may be inverted full of *Mercury*, and let down into the *air* within the Veſſel A B, plunging the Mouth into the Stagnant *Mercury* G H: then fill with *boiling* Water the Veſſel A B up to the top, and ſtop the Mouth A D with a round Glaſs Plate ground to it, and perforated with a ſmall hole; cover this with a Bladder, and binde it cloſe. The Water will gradually cool, and ſo condenſe it ſelf, cauſing part of the Veſſel A I to be empty; and at the ſame time the *Mercury* in the included Cane E F will ſubſide, ſuppoſe to K, where it will ſtop, and fall no farther. Then prick the Bladder over the hole in the Glaſs Plate, and immediately upon the *Ingreſs* of the *air*, the *Mercury* in the Cane will haſtily mount up, and refill the whole Cane E F, although it were higher, provided it exceed not the *Mercurial* Standard.

Note that K L is about the fourteenth part of the whole height of the Water M L (for what Cauſe may be told preſently) but when it does exceed it, (as it may ſometimes happen) 'tis from two *Cauſes*; *Firſt*, either the Water wherewith the Veſſel is fill'd, was not poured in ſo hot, that the *vacuum* left by it, in condenſing, is capable of receiving all the *Quick ſilver* falling from the Cane E F; for when the ſpace A I left by the Condenſing Water, is fill'd by the ſubſiding *Mercury* (which falling into the Veſſel G B raiſes all the Water) there can no more *Mercury* deſcend out of the Cane E F, and ſo it will be above $\frac{1}{14}$ of the height M L.

Or *Secondly*, the other cauſe may be, when this void ſpace A I is indeed ſufficient for the *Mercury* in the Cane, but not for the *Air*; which may riſe either from the *Mercury* in the Ball, or from the Water in the Veſſel, which *air* requiring a larger field to expatiate in then the void A I, may poſſibly make

make some impression upon the *Superficies* of the Water, and so communicate it to the Cane, and bear up the *Mercury* a little higher than the bare Weight and Pressure of the Water would have sustained it at.

An Experiment

From whence is shewn, the efficacy which the Pressure *of another* Fluid *joyned with the* Air, *has upon the sustained* Mercurial Cilinder.

Tab. 5. *Fig.* 2. THe *Vacuum* being made with the Cane A B C, wherein the simple *Pressure* of the *air* raises the *Mercury* to D, the usual height of 28 $\frac{6}{10}$ Inches, pour Water upon the *Stagnant Level* E B, and fill it up to A, and you shall see the *Level* D raised to F, and the space F D will be $\frac{1}{14}$ of the Water A B poured in: and that because, to the *weight* of the Cilinder of *Mercury* D F, the *weight* of the other *Cilinder* of *Water* will upon trial be found equal, having the same *Basis*, and of the Height of A B.

Brac. $\frac{1}{4}$

But if instead of *Water* the same space A B be fill'd with Oyl, the *Mercury* will rise to G onely; if with *Spirit of wine* to H; whence we may (from the proportion of the height of the Fluid A B encompassing the Cane, to the height of the increase caused by that *Fluid* in the *mercurial Cilinder* above the first Height of 28 $\frac{6}{10}$ Inches caused by the *air*) find the Proportion of Specifick Gravity between the *mercury* and any of the Ambient Fluids.

1 *Brac.* $\frac{1}{4}$

And likewise as easily that of the Specifick *Gravities* of the *Fluids*, in respect of each other.

The same may also be obtained without a *Vacuum* with a plain Cilindrical glass A B in the former *Fig.* into which by putting a little *mercury*, and the small Cane A C (now supposed open at each end) and then pouring an *equal*

quantity

antity of ſeveral *Fluids*, *ſeperatim* upon the Superficies f the *mercury* EB, and all to the ſame Height, ſuppoſe A ; om the different heights of the *mercury* in the little Cane G, HD, cauſed by their reſpective *gravities*, we may not nely have the Proportion of their *Specifick gravity* with he *mercury*, but alſo that of the *Fluids* compared with ne another.

Note, that (in this, and all like Experiments) where it appens that the inward or outward Level of the *mercury* altered by the *Preſſure* of ſome *fluid*, or otherways, then he Letters pointing at thoſe *operations* in the Figures, are ppoſed to be removed to the places requiſite, and ſucceſſive- y follow the Level, as it gradually moves from place to lace.

An Experiment

Shewing, that where the Air *preſſes not at all, a* Vacuum *may be made not onely with* Mercury, *but alſo with Water, to any height of the* Tube, *provided leſs than that whereto it uſed to be ſuſtained by it.*

LEt there be a Glaſs Veſſel AB containing about 6 *l.* of Water and the Mouth A big enough to receive the Cane CD 22 ½ Inches long ſealed at C, but Obliquely open at D: this Cane muſt have at A, (the place whereto 'tis let down into the Veſſel AB) two ſmall Anulets of Glaſs cloſe together, that the Bladder with a hole therein may be tyed very faſt between thoſe two Rings: then fill the whole Veſſel AB with *Water* as *hot* as poſſible, and the

Tab. 5. *Fig.* 3. 1 *Braccio*

the Cane C D with *cold*, put upon it at the lower end D the Plate of Glaſs E fitted to ſhut the Mouth of the Veſſel A B: Immerſe the Cane therein, turn down the Bladder, gather it together, and bind it cloſe about the Neck of the Veſſel, having firſt preſt out the Air from its Folds. Now as the Water cools, part of the Veſſel F G will be empty, and likewiſe (as in the former Experiment) part of the Cane C H, where the *Water* will reſt, nor move but upon ſome alteration of the External *Heat*, and *Cold*; but upon pricking the Bladder, the *Air* forcibly entring upon the Level of the Water in the Veſſel, will refill the Cane as at firſt.

It was thought by ſome, that the *water* in the Cane does not fall at firſt when the *Vacuum* is made to the ſame Level with that in the Veſſel, (ſuppoſing the ſpace A G capable of receiving it) it may be from a cauſe mentioned in a foregoing Experiment (*i. e.*) from ſome *Air* which raiſes it ſelf from the Water into the void ſpace, perhaps too narrow for its full Expanſion: whence they imagine, that if the Experiment were made with *wine*, *oyl*, *ſpirit of wine*, and other *liquors*, from a *greater* or *leſſer Vacuum* remaining in the Cane, it might be determined which of the *Fluids* has moſt *Air* diſperſed through its Particles.

An Experiment

Firſt made in France, *and after by our* Academy; *whence 'tis probable, a more cogent Argument for the* Preſſure of the Air *may be drawn.*

M. *Pecquet* in his Book of *New Anatomical Experiments*, writes, that it has been obſerved by many, that

that the height of the *Mercurial Cilinder* in *Vacuo*, varies according to the places where the Experiment is made; whence in higher places 'tis leſs; and in lower places, and deep pits, greater: provided the height be pretty conſiderable, as that of the higheſt Mountain of *Auvergne*, at the top whereof the *Mercury* wants much of the uſual height: which has been ſaid to happen, becauſe the higher *Air* which is found upon the tops of vaſt Mountains, having a leſſer weight upon it, makes a more faint *Preſſure*, nor is able to raiſe the *Mercury* to that height whereto the lower *Air* of Valleys and Plains eaſily mounts it. Howſoever, the truth of this aſſigned cauſe may prove, of which 'tis not at preſent our intent to diſcourſe; yet we have obſerved the very ſame Effect on the higheſt Tower at *Florence*, which is 271 Foot high: as likewiſe on divers of thoſe ſmall Hills which ſurround the City: and we find it manifeſt, that the height of the *Mercury* varies in different parts of the Tower, or Hill, ſubſiding as we *aſcend* towards the *top*; and as we *deſcend lower*, and *lower*, it gradually *riſes*, till being brought into the plain, it ballances it ſelf at the uſual *Station*. But to make this Effect ſenſible, at leaſt 100 Foot is requiſite This obſervation has given ſome ground to hope, this Inſtrument might be improved to ſhew and determine exactly the ſtate of the *Airs compreſſion*; believing that the divers Heights of the *mercurial Cilinder* ought infallibly to ſhew the various *Preſſures of the Air* upon the Stagnant *mercury*, upon account of the different height of the *Atmoſphere* above the ſaid Level. But from the many *inequalities*, and *irregular movements*, which in a long Series of Obſervations we have taken notice of, this thought is rendred dubious; for this Inſtrument being let alone fixt and unmoved in any place, its variations were very ſmall, and ſeldom above 2 or 3 degrees, which came onely from the different temperament of *Heat* and *Cold*; and on the contrary, very notable variations to above 12 *Degrees* have ſometimes happened from other reaſons to us unknown and hid.

Br. 142.

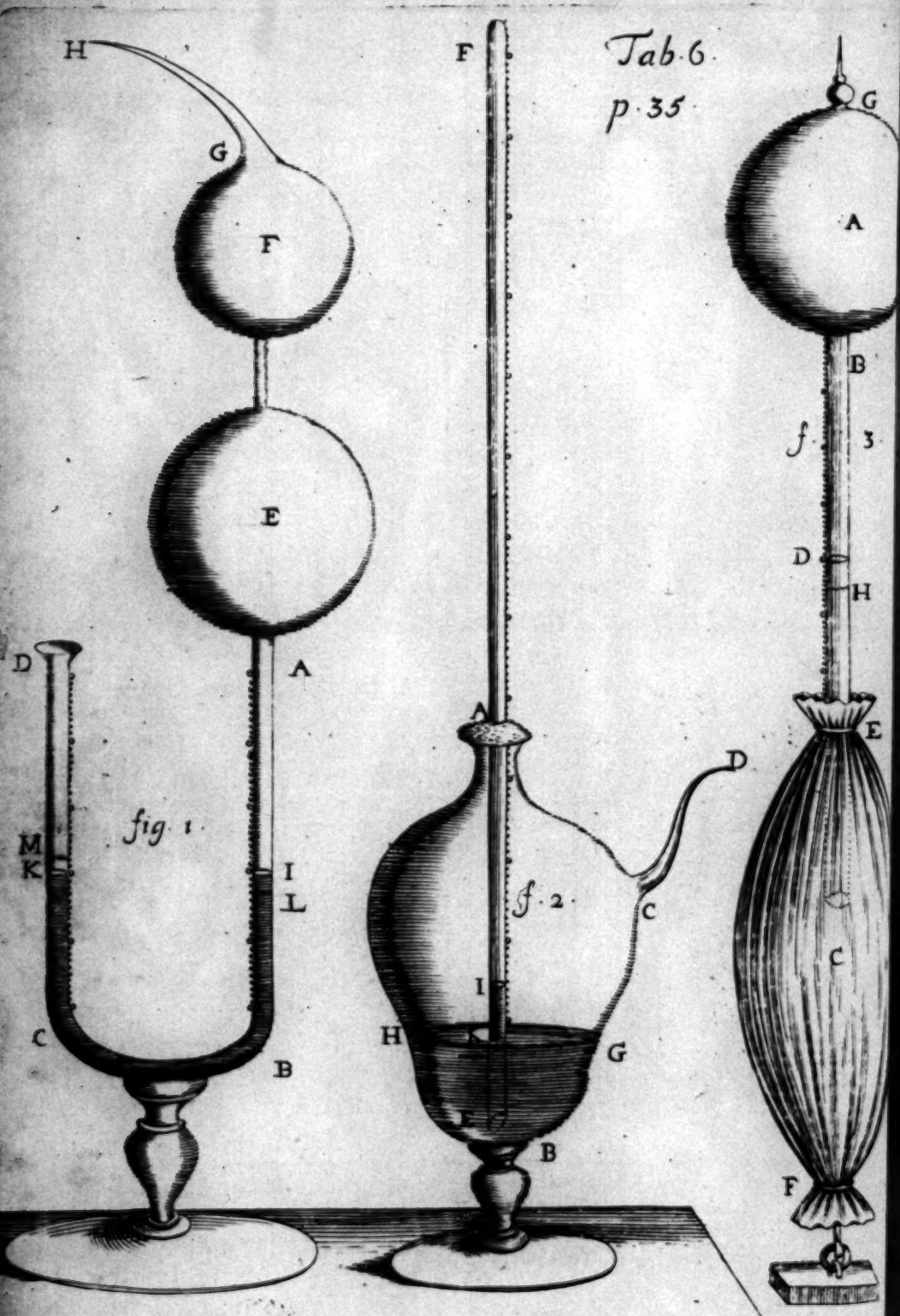
Br. 50.

Nevertheleſs, to arrive at this Knowledge by other means,

more certainly and assuredly, we thought of making the next following Instruments, whereon though the External Accidents of *Heat*, and *Cold* have some Effect, altering them from their true and simple Operation: yet these disadvantages are not so insuperable, but the accuracy and care of the diligent Observer may easily avoid them.

THE

Tab. 6
p. 35



THE

DESCRIPTIONS

OF THE

Inſtruments:

SHEWING,

The various Alterations happening in the State of the Natural Compreſſion of the Air.

The firſt Inſtrument.

CHuſe out the ſmootheſt and eveneſt Glaſs Cane you can, being ſomewhat larger than an ordinary Gooſe-quill, which muſt be bent in the Figure of ABCD, with its two Arms AB, CD *Parallel*, and very near of the ſame length, as is repreſented in the Figure; this muſt be acurately divided into equal Degrees, ſo that the *Decimal* Marks upon each Arm, may be upon the ſame *Level*: which to do more eaſily with the ſmall Buttons of *Enamel*, you may glew on the out-ſide of the Arms two Liſts of Parchment, equally divided; which through the Tranſparent Glaſs Cane will readily point at the place where the Buttons ought to be fixt. The Arm CD is to be widened like a Trumpet at D, and the other Arm is to be

Tab. 6. *Fig.* 1.

Smalto.

joyned to one, or more Glaſs Balls, as E, F, which are empty, and capable of containing ſome Quantity of *air*; the laſt of which muſt have a Beak G H drawn ſmall to be Sealed with a flame, as occaſion requires: Then pour in ſome *Quick-ſilver* at the Mouth D, which (the Veſſel being open at each end, and the Two Arms of an equal ſize) will ſtand both ways, at an exact *Level*, as I, K. The Inſtrument, being ſo prepared, is to be carried to the foot of ſome Tower, where let it reſt 'till the *air* contained within the Balls, may be of the ſame Temperament with the *Ambient*: then preſently Seal it with a flame at H, but be ſure to be very quick in doing it, leſt the included *air* ſhould alter by heat of the flame. This done, let there be one upon the Tower, to draw up the Inſtrument with a Pack-thread (faſtned to the upper part thereof, ſo as not to invert the Beak;) and when at the higheſt part of the Tower, let it ſtand upon a plain, as at the foot thereof it reſted; then examining the *Temperature* of the *air* above, and finding it the ſame with that below; you may perceive, that whereas at the foot of the Tower, the *Quick-ſilver* reſted at I, K; at the top of the Tower the *Level* I will be ſenſibly depreſt, as to L, and the *Level* K in the ſame Proportion raiſed for the ſpace M K: cauſed, as they ſay, by the more vigorous *Preſſure* which the lower *air* makes upon that included in the Balls E, F, in compariſon of that above; by which the *Level* K is more lightly preſs'd.

Remember, that every little difference of *Heat* and *Cold* between the *air* above, and thar below, is able to cauſe a variation in the *Levels* of the Two Arms A B, C D; and ſo alter what ſhould have happened from the diverſity of *Preſſures* made by the *air*: wherefore this *Inſtrument* is a ſort of *Thermometer* for the *air*; and that, for the moſt part, very nice. Therefore in the making this Experiment, chuſe the Dawn of the day before the *Sun* is up, or any other cloſe Seaſon; that the *air* above and below may be of an equal Temper, as near as poſſible; nor let the time between the obſervation made at the bottom and top of the Tower be long; take

care

care alſo not to ſtand too near the *Inſtrument*, when you obſerve the Degrees, which ſhould be done quickly, and be ſure not to breathe upon it, leſt it heat the Balls: which ſhould be of as thick Glaſs as may be, to defend the better from any External Impreſſions, the *air* contained in them.

All this diligence muſt likewiſe be uſed in the management of the Three following *Inſtruments*, they being not at all leſs Nice, and ſubject to cauſe the ſame miſtakes as this firſt.

The Second *Inſtrument*.

LET there be a Veſſel of Glaſs AB containing about two Quarts, with its Beak C D open; pour into it ſo much Mercury as will cover the mouth E of a ſmall Cane E F 11 ½ Inches long, and open at both ends, but cut ſloping at E, and round at F; which being divided into equal Parts, or Degrees, is to be immerſed into the Stagnant *Mercury* G H; and the ſpace left round the Mouth of the Veſſel A is to be cloſed with Cement to ſhut out the *air*; being ſo made, carry it to the foot of a Tower, and let the *internal air* be reduced to the ſame Temperament with the *External*; immediately Seal it, and let it be drawn up to the top of the Tower; where having placed it on a Plain, you will find the *Mercury* ſomewhat raiſed within the Cane, ſuppoſe to I: which Riſe, (they ſay) follows alſo from the ſame Reaſon which we gave in the Deſcription of the former Inſtrument, *viz.* The *lower air*, ſuch as is included in the ſpace A C G H, has a greater force and power upon the *Level* of the *Mercury* encompaſſing the Cane, than the *higher air* has, which preſſes upon the *Level* I, entring in at the Mouth of the Cane F, ſo that it raiſes the little *Cilinder* I K, to make a juſt *Equilibrium* between thoſe two *Momentums*, or Powers. *Tab.* 6. *Fig.* 2. ½ *Braca*

The

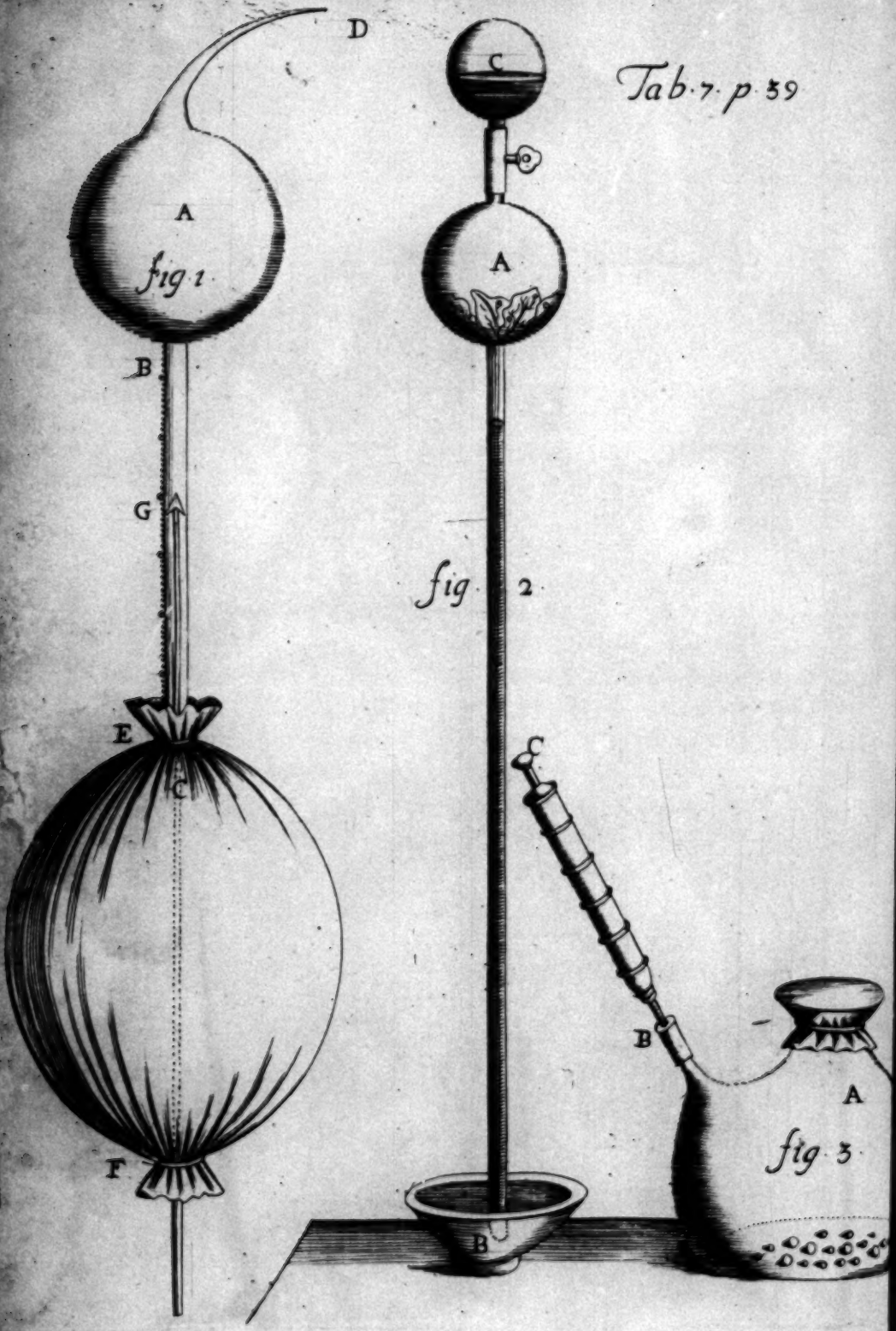
The Third *Inſtrument.*

Tab. 6. *Fig.* 3. $\frac{1}{4}$ *di Brac.* $\frac{2}{3}$ *di Br.*

BLow a Glaſs Ball A $7\frac{6}{10}$ Inches in *Diameter*, with its Neck B C about $15\frac{3}{10}$ Inches long, divided into very minute Degrees, pour into the Ball ſo much Water as will fill half the Neck, which is the ſpace C D: ſtop the Mouth C with a Finger, and plunge it into the Water in the Bladder E F, which is kept from being fill'd to its whole *Spherical* Capacity, by means of a Weight at pleaſure hung at F: cloſe then the folds of the Bladder, and bind it very ſtrait round the Neck B C, at E, taking care when you bind it, to pour in Water till it runs over; ſo to be ſecure that no *air* is included, which might any way alter or ſpoil the due and right Operation of the *Inſtrument*; Every thing being performed after this manner, at the foot of a Tower, faſten to the Ball at G, a ſtring let down from the top of the Tower; and having obſerved the Degrees whereat the Water ſtands, let it be drawn up: when again obſerving, it will be found Depreſt ſome Degrees lower, as to H, which will be more or leſs according to the preſent State of the *air*; and the greater or leſſer height of the Tower.

This alſo they ſay happens, for as much as the Bladder E F is encompaſſed with the *air* of the *higher* Region; and ſo not ſufficiently armed *externally* to reſiſt the Force made on it by the *air* of the *lower* Region (which is included in the ſpace G D) in Dilating it ſelf; whence it muſt neceſſarily yield to enlarge its *internal* Capacity, which the ſmall Bulk of Water D H ſinks down to fill out.

The


D
A
B
G
E
C
F
fig 1
C
A
fig 2
C
B
A
B
fig 3

The Fourth *Inſtrument.*

CAuſe a Glaſs Ball to be made A, with its Neck B C like the Third Inſtrument, onely it muſt have an open Beak drawn very ſlender D, round the Mouth of the Neck C bind the Bladder E F very cloſe: this Bladder is to have in its lower Ligature F a ſmall thread of Glaſs, or Braſs-wire, which paſſing through the Bladder is to enter into the Neck of the Ball B C, and ſo point at the Degrees it is minutely divided into: let this *Inſtrument* be carried to the foot of the *Tower*, ſeal it as the other at D, and take notice of the Degree pointed at by the *End*, or *Dart* G: raiſe it then to the top of the *Tower*, and you will find the *Dart* higher than before, by ſome Degrees. *Tab.* 7. *Fig.* 1.

To give the reaſon of this Effect, they conſider, that the Veſſel is filled with *air* of the ſame Temperament with that *below*, which as it finds one part of the Veſſel leſs Solid than the Glaſs, yielding, and eaſie to be diſtended, ſuch as is the Bladder E F, ſo it no ſooner perceives it ſelf relaxed from the Priſon of the ſurrounding *air*, by being raiſed to a higher place; but it immediately endeavours to enlarge it ſelf, and be at liberty; which it Effects, by ſwelling the Bladder a little more: Now whilſt this by being ſo puffed up comes nearer to a Spherical Figure, the tranſverſe Diameter of the *Ellipſis* E F is ſhortned, as the bottom F is gradually raiſed, when alſo the *Index* F G faſtned thereunto, by obeying its Motion, riſes higher in the Neck B C, and ſo comes to point at a higher Degree than G.

Various.

Various Experiments made in *Vacuo.*

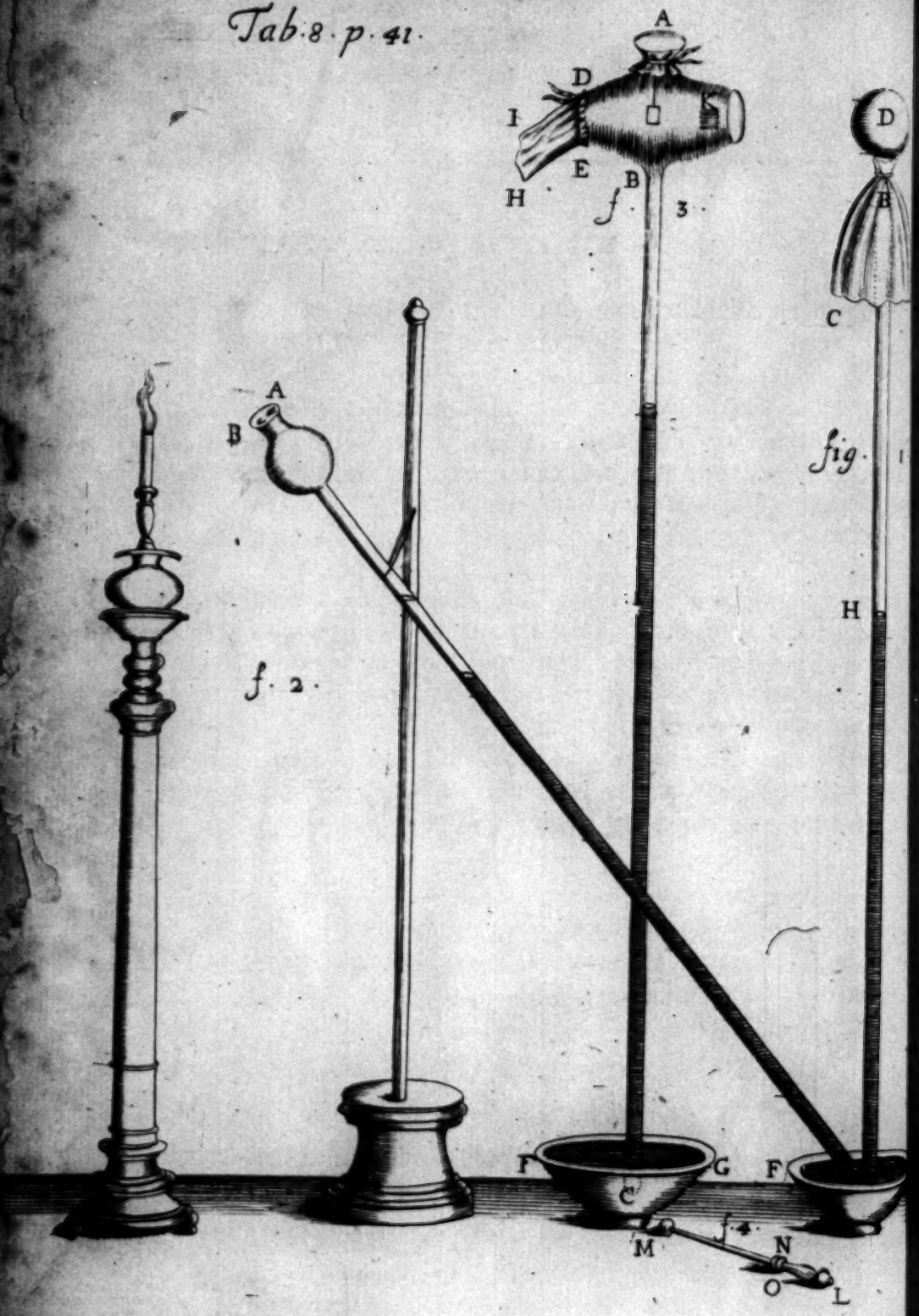
FRom the *Series* of the afore-mentioned Experiments, *Torricelli*'s thought touching the *Airs Preſſure* upon all Inferior Bodies, ſeems fully confirmed. And tho it may be a daring undertaking, and full of hazard, to determine of the Cauſes where *Geometry* gives no *Illumination*; yet this *boldneſs* is never more excuſable, nor the *danger* more like to be avoided, than when our Underſtanding, onely by a Path of many, and all agreeing Experiments, makes toward the attainment of its deſire; which tho it may ſometimes fail off, yet it is ſatisfied in approaching as near as may be towards it. Since then it appears from the Effects already mentioned, that we have gained ſome reaſonable probability of ſuch a Preſſure; it was judged not altogether a fruitleſs labour, to proceed to make divers *Experiments in Vacuo:* and obſerve, whether the manner of their operation would ſucceed contrary, or any way different to what they appear, when environed on every ſide with the free *Air.*

Experiments

To know whether ſmall drops of Liquid Bodies, being freed from the Airs Preſſure *encompaſſing them, loſe the* Spherical *Figure they naturally are off.*

SOme have Attributed to the *Preſſure* of the *air*, that generally known Obſervation of the drops of *Mercury*, or

Tab. 8. p. 41.



or any other Fluid; which ſpurted, or raining through the *air*, or let fall upon any dry, or duſty body, always are nearly of a *Globular Figure:* wherefore they were willing to try it in *Vacuo*, imagining there might then happen ſome notable Variation. But *Experience* it ſelf ſhewed, That the Effect proceeded from ſome other cauſe, than the *airs Preſſure*; for having made the *Vacuum* in the Veſſel A B, the cavity A being quite void, by turning the *Stop-cock* there was let fall ſome drops of Water, or *Mercury* out of the Ball C upon ſome *Colewort-leaves* included in the Ball A, (which had ſome drops of Dew hanging on them, with which they were gathered;) theſe Drops that were admitted, contracted themſelves as round, as if they had been upon a growing Plant. *Tab.* 7. *Fig.* 2.

So when the *air* in the Veſſel A was condenſed, or rarefied by means of a *Syringe* C B; the Drops of Water, or Mercury, ſprinkled upon the bottom of the Veſſel were not altered from their uſual ſhape. *Tab.* 7. *Fig.* 3.

An Experiment,

Shewing the Effect of Heat *and* Cold, *applyed Externally to the void ſpace.*

BInd the Bladder A B C under the Ball D, make the *Vacuum* therein, turn the Bladder upwards to be tyed there likewiſe; then with a Cane of Glaſs, or any thing elſe that will not alter, or bend, take the exact height of the *Mercurial Cilinder* H G, from the Stagnant *Mercury* E F: after this, fill the Bladder with *hot water*, and ſoon after meaſuring, you will find the *Cilinder* a little depreſs'd below the former height. This Obſervation made, throw out the *hot water*, let it ſtand till it returns to the former height *Tab.* 8. *Fig.* 1.

H, and then fill the Bladder with *cold water* mixt with beaten *Ice*, and *Salt*, and in a little while measuring (as before) you will observe the *Cilinder* notably raised.

Nor will we omit, that the Hot Water made use of in this Experiment raised a *Thermometer* of 50 *deg.* to 48°. and with the same Heat shortned the *Mercurial Cilinder* one 146*th* part of the whole Height. And that the Cold Water increased to one 50*th* part, when in the same Water the *Thermometer* came to 11 *deg.* $\frac{2}{3}$.

If then a little *air* be admitted into the Ball D, this because it becomes very thin, by reason of the Dilatation it has in the void space; quickly imbibes *Heat* or *Cold*, and by its Rarefaction, or Condensation causes that the Alterations in the Rise, or Fall of the *Mercury* are much more sensible, and swift.

An Experiment

To manifest whether the Air *be that which serving as a* Foile *to the lower Superficies of a* Lens *of Glass, reflects that second Image inverted more dimly and faintly which we see of a Flame, or any other Object Visible there, as* Kepler *thinks it is.*

Astr. Opt.

Tab. 8. *Fig.* 2. ON the Mouth of the Glass Vessel A C we cemented with hard cement a Glass *Lens* A B: this Mouth had its Lips turned a little outward, and made smooth for the more easie fastning on of the *Lens*; then filling the Vessel with *Mercury*, we made the *Vacuum*; and inclining the *Tube* we tyed it to the *Rest*, as in the Figure; and having made the Room dark, and bringing a Candle near it, we observed in the *Lens*, the two Images of the Object, as is usual: one

of

of theſe was leſſer, but very vivid, and always direct; which was reflected from the *Convex* outward Superficies. The other was indeed larger, but more obſcure and languid, and inverted, which nevertheleſs was not loſt, though the imagined *foil* of *air* was wanting (on the *Concave* inward Superficies of the *Lens*) by reaſon of the *Vacuum* made.

In making this Experiment, we always us'd to put three or four Fingers depth of Spirit of Wine upon the *Mercury*, that when the Veſſel was Inverted to make the *vacuum*, the Spirit getting uppermoſt might waſh, and cleanſe the *Lens* from all foulneſs left there by the *Mercury*, leſt that ſhould give ſome occaſion to imagine it might ſerve inſtead of the Foil of *Air*. But nevertheleſs (as we ſaid) the Appearance of the Two Images was the very ſame; and when we permitted the *air* to fill the void ſpace, it gave not the leaſt Difference.

An Experiment,

To know whether Amber, *or other* Electrick *Bodies require the* Medium *of* Air *to make them Attract.*

PRepare a Veſſel of thick Glaſs, big enough to ſtir, and turn the Hand within the upper part thereof A B. Let it have Three Mouths A, C, and D E; let A be open cloſed, C with a Bladder, and reſt it upon a little bundle of Cotton, or ſome ſoft Cuſhion Floating upon the *Mercury* in the Baſin F G, that ſo the great weight of *Mercury* to be poured in may not burſt the Ligature, or break the Cane. The Mouth D E made large enough to receive a Mans Hand, muſt have an Edge, or Lip of Glaſs round it, about which muſt be tyed very cloſe and faſt a large *Bladder* open each way, as D E, H I, through this the Hand is to be put into the Veſſel, with a ſmall piece of the beſt *yellow Amber*, ha-

Tab. 8. *Fig.* 3.

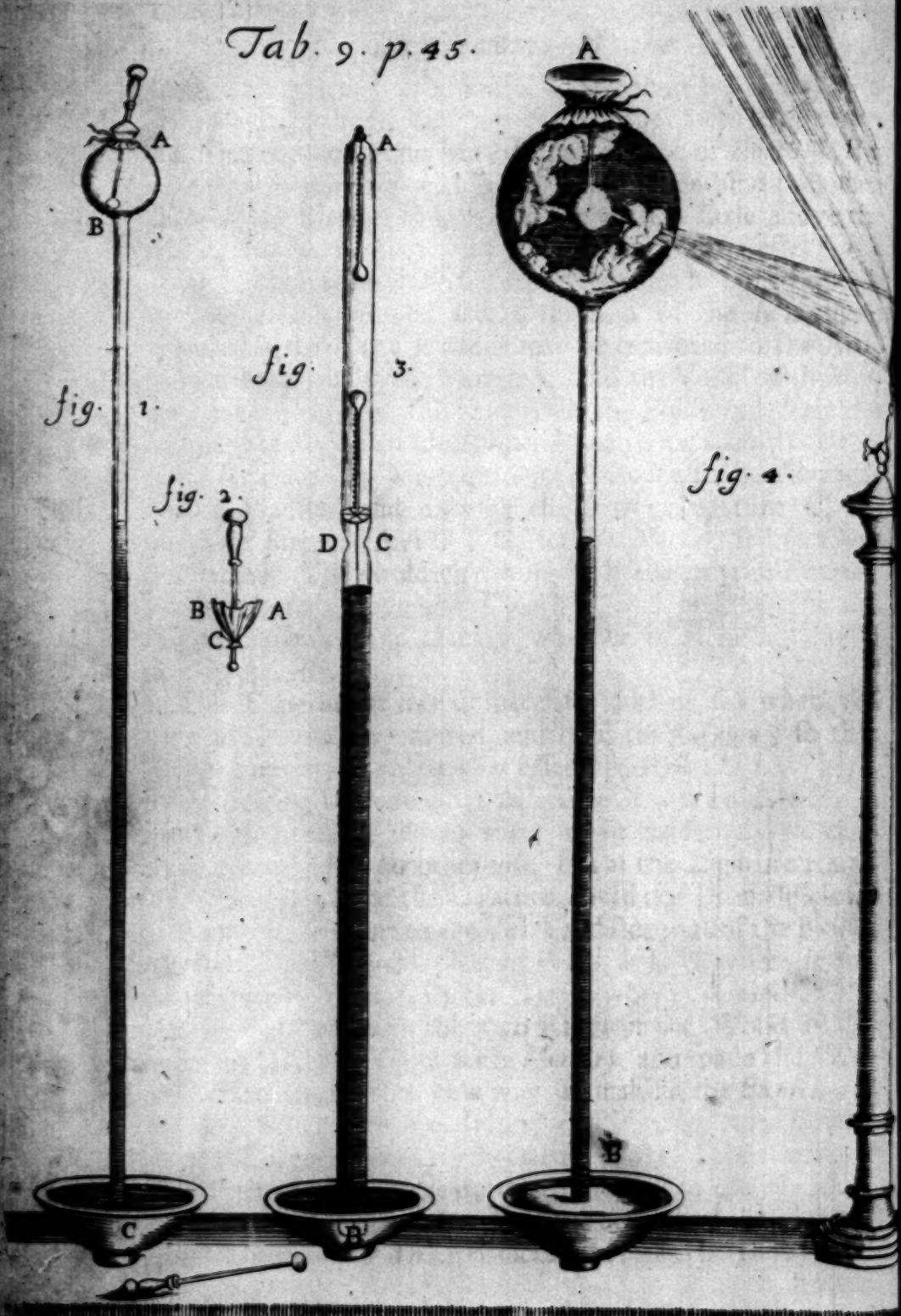
ving first placed in the Vessel a little light bit of *Paper*, or *Straw* where the *Amber* may readily approach it, when it has been rubbed, and heated upon a piece of *cloath* K, fixed for that purpose within the Glass: then bind the other side of the Bladder H I, round the wrist, a little above the Pulse, that so the Hand may move freely in the Vessel; and let the place where the Ligature is made, be armed with *a ring of Leather* bound fast to the skin of the Arm, upon which Ligature the Bladder may be cemented to the Arm, which done, fill by the Mouth A, and the Vessel with *Mercury*, taking care in filling it, that the Folds and Wrinkles of the Bladder be all filled with *Mercury*, that as little *air* be left as is possible; when quite filled, close also the Mouth A with a Bladder, and untying the lower Ligature C, beneath the Stagnant Level F G, let the *Mercury* fall to make the *Vacuum*. Then holding the *Amber* between your Fingers, rub it strongly upon the Cloath K, and present it to the *Paper* or *Straw*; and observe whether it attracts it, as it do's in the *Air*.

This Experiment was unsuccessful with us, for whenever we made it, the *Air* entered, and fill'd the *Vacuum*; so that we were never able to see what Effect the *Amber* had. Wherefore reflecting thereon what Aperture it was possible for so great a quantity of *Air* to enter at so suddenly; we concluded, it could be no otherwise, but at the Ligature round the Arm. But since the Ligature could not be made closer without manifest hurt to the Veins, and stoppage of the Blood, we made use of a small piece of *Wood*, as L M. with a round bit of *Amber* fastned to the Top: wherefore binding the Bladder H I, between the two Rings in the Wood N O, we again fill'd the Vessel with *Mercury*, and made the *Vacuum*. Neither did this new way of making the *Experiment* succeed; for though the *Air* indeed did enter more slowly, (as it will always enter) yet the endeavour of the External *Air* to get in was so great, that it forced in the Bladder; and therewith the wooden Instrument beyond the piece of Cloath, so that the *Amber* could by no means be rubb'd and

Tab. 8. *Fig.* 4.

heated

Tab. 9. p. 45.



heated thereon; nay, it was impoſſible to draw back the Wood, and move it forward and backward as was requiſite, until the *Air* getting in, had fill'd the Veſſel, and ſo the *included* of the ſame with the *External.*

Yet ſtill deſiring ſome fruit of this *Experiment*, we thought of making another Veſſel, as ABC: perſwading our ſelves, that therewith we might more eaſily obviate the inconvenience of the *Airs* entring, and alſo the difficulty of moving the Wooden Inſtrument forward and backward. Wherefore, filling at the Mouth A, this Veſſel, having firſt cloſed its other Mouth C, and reſted it as in the former Experiment upon the Cuſhion as was directed; we then bound the Bladder ABC about the piece of Wood, and thruſt it into the *Mercury*, ſo as the end thereof, whereto the *Amber* was faſtened, might reach a piece of Cloath ſtuck to the ſide of the Glaſs. Then we threw in ſome ſmall bits of *Straw*, and turning down the Bladder, we bound it faſt down the Neck A, the *Vacuum* made, by moving the Wood or Handle which ſtood out, we rubb'd the *Amber* upon the *Cloath*, and when we thought it might be hot, we apply'd it to ſeveral pieces of *Straw*, which in the Deſcent of the *Mercury* ſtayed to the ſides of the Glaſs; but we could never perceive that any were attracted by the *Amber*. *Tab.* 9. *Fig.* 1. *Tab.* 9. *Fig.* 2.

But Note, that this Experiment is not to be much accounted of, nor the Effect to be Attributed abſolutely to the want of *Air*; for in ſuch a Veſſel at leaſt a ſmall quantity always gets admiſſion; nor could we ever ſo bind the Ligature, but by ſome unſeen ways it deceived us, which it may be happened from the Motion required in this Experiment to heat the *Amber*; ſo that we may almoſt judge it impoſſible, but the Ligature muſt be relaxed; at leaſt, ſo much as is needful to let in the ſubtil *Air*. 'Twas obſerved alſo, that when the Veſſel was full of *Air*, though we rubbed the *Amber* with great force upon the piece of Cloath B, yet it had no Attraction; a thing which at firſt made us ſuſpect that ſome Dregs of the *Mercury* adhered to the Cloath, whence the *Amber* by rubbing might acquire ſome foulneſs

to

to close and stop up the imperceptible *pores* of those passages by which the attractive Virtue issues out; which suspition seem'd more probable, because we already knew some Liquors wherewith the *Amber* being wetted (or any other *Electric* substance) refuses to attract. But since we after found, that the same *Amber* rubbed upon a piece of Cloath often dipped in *Mercury*, did nevertheless draw with great force, we thought the humidity of the Gum (made use of to fasten it to the Glass, being imbibed by the Cloath) might impede the Effect: we therefore sealed a piece of *Shamois* instead of Cloath, with Wax to the side of the Glass, that all manner of suspition of any wet soaked up, might be avoided. Nevertheless, all this diligence was in vain, for whether the Vessel were full, or Empty of *Air*, the *Amber* attracted not, which is all we can with truth report of an Experiment attempted so many ways unsuccessfully.

An Experiment

Examining what may be the motion *of the invisible* Effluvia *of* fire *in* Vacuo.

BEing already satisfied by many Experiments, that the heat of *Fire* is not equally carried every way, but diffuses it self, and has greater Vertue upwards than any other way comparatively: 'Twas imagined, that on the contrary, if it were Experimented in *Vacuo*, some *variation* might happen, from whence some probable conjectures might be drawn of the *Principles* of the Natural Motion of *Fire*, and that by such an Instrument.

Tab. 9. *Fig.* 3. *2 Brac.* Let the Cane AB be about 46 Inches, long into which (being open at A) put a *Thermometer* of 50 *deg.* from one end to the other, made flat at that end, where sealed to stand

ſtand faſt at the ſtrait place of the Tube CD; and leſt when the *Quick-ſilver* comes to be poured in at the Mouth B, this *Thermometer* ſhould fall upon that placed above, and ſo by the colliſion of the Balls, one or both be broken; there may be faſtned to the bottom a Thread coming out of the Mouth B, by which it may be ſtayed when the Cane is turned with the bottom upwards to be filled. The firſt *Thermometer* being thus placed, let there be put in another exactly correſpondent to it; this incloſing the Mouth of the *Tube* A, muſt be faſtned there by its ſealed end with the ſame Glaſs Cement at the fire. The Inſtrument being fitted, the *Mercury* muſt be poured in, and the *Vacuum* made. Note, that the ſtrait CD, muſt be above the height of 30 Inches, that the whole *Thermometer* may be expoſed to the Obſervers view, and not buried in the *Quick-ſilver*. When the Cane is fix'd, and immovable, apply a great Degree of *Heat* to the void ſpace, by the help of Two Iron Balls heated red hot, and held at an equal diſtance from the Cane, but unequal from the Balls of the *Thermometers*, inclining more to the lowermoſt, that ſo the *Heat* (which is always carryed upwards by the *Air*) may be the more equally diſtributed to the two Balls of the *Thermometers*; we having very often repeated this Experiment, yet cannot otherways Affirm, but the upper *Thermometer* was indeed moſt affected by the *Heat*; we confeſs the difference is very ſmall, in compariſon of what we obſerved in the open *Air*; for whereas that was ſometimes five Degrees in the *Vacuum*, it never exceeded two. Neither did ſome think it would be otherwiſe, becauſe the *Air* encompaſſing the two Balls, was more heated in its upper part, and ſo gave a greater heat to its neighbouring *Thermometer*.

An Experiment
Of the Motion of Smoak *in Vacuo.*

Tab. 9. *Fig.* 4. *Paſtiglia Nera.*

WIthin the Ball of the Veſſel A B hang a Paſtile of Perfume or other *Bitumen* of a dark Colour, upon which the Fire has an eaſie Effect. Then making the *vacuum*, caſt the *Rays* of the *Sun* thereon with a *Burning-glaſs*, you may preſently perceive the Smoak iſſue from the Cake, which inſtead of mounting upwards, as it uſes to do, as ſoon as parted from the Ball, or Cake of combuſtible Matter, deſcends like the ſpout of a Fountain in a *Parabola*: the *Air* being admitted to move it, it immediately riſes to the top of the Ball.

Many *Experiments* having been made, that did not require any peculiar *Apparatus* of *Inſtruments* (as moſt of thoſe hitherto related have) it will be adviſable, to avoid tediouſneſs in the Diſcourſe, to give a ſhort Deſcription of an *Inſtrument*, and of its capacity, (the ſize of our Plates being too little to repreſent it in its full proportion;) and then ſuccinctly Explain what Method we took to menage it moſt commodiouſly and eaſily. That ſo any who deſire to try, and compare the Truth of our Experiments with their own, may be able to do it; at leaſt, till they light upon a more ſafe and eaſie way.

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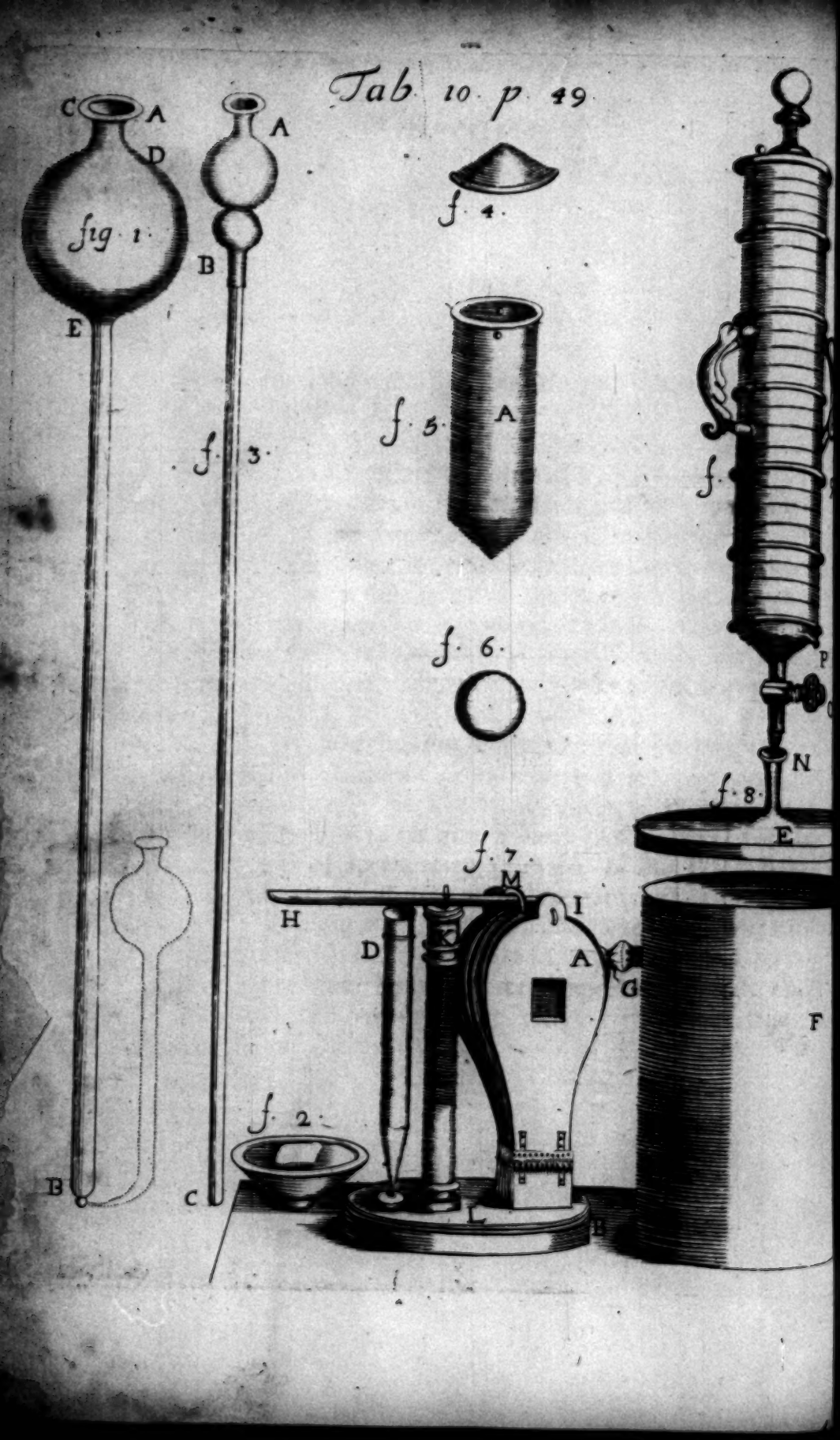
Tab 10 p 49
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The Deſcription of a Veſſel made uſe of in many of the following Experiments.

THE Veſſel then is AB made of Glaſs, whoſe Mouth AC is turned outwards flat. The bigneſs of the Neck or Mouth is three Fingers, the length of the Neck AD is four Fingers; the Diameter of the Ball DE is about 7 ½ Inches; the height of the Cane ED about 46 Inches. Cloſe the lower Mouth B with a Bladder, and ſet it upon a little Leather Cuſhion, ſwimming upon the *Mercury* in the Baſin, (*Tab* 10. *Fig.* 2.) then fill it at the Mouth AC; but becauſe in filling it, the *Mercury* falling directly upon the *Tube*, will intercept and detain a great quantity of *Air* therein; The ſmall Funnel ABC (*Tab.* 10. *Fig.* 3.) was made to prevent it, being of equal length with the Veſſel: keeping the Body of this AB always full of *Mercury*, there can no *air* get into the Shank BC: ſo the *Mercury* falling gently into the Veſſel, raiſes the *Air* before it quietly. When filled, we cover the Mouth AC with a Glaſs Cover a little Convex (*Fig.* 4.) and then with a Bladder bound faſt about with a waxed Thread below in the ſmall of the Neck. Put then your hands under the Ball on each ſide; and gently lifting it up, take away the Cuſhion, and Immerſe the Mouth B into the Stagnant *Mercury* in the Baſin: looſen the Knot of the Ligature at B, and the *Mercury* by its weight falling, will open it, and make a *Vacuum*.

Tab. 10. *Fig.* 1. ½ *diBrac.* 2 *Brac.*

When there is occaſion to put ſuch things in the Ball as may not be covered with *Mercury*, either to avoid mixing therewith, as Liquors; (which we put in the Veſſel A, *Fig.* 5.) or to prevent their being ſtifled therein, as Animals; we then uſe to leave ſo much *Air* in the Neck of the great Veſſel AD, (*Fig.* 1.) as may ſerve to receive this little Veſſel, or the Animal we would include therein. This *Air* when

the *Vacuum* is made, dilating it self to so large bounds as the capacity of the Ball will be so extreamly rarified, as if almost it were not there at all, that in reality, it will be no impediment to any of the Effects desired to be observed.

But when we would incloſe Fiſh therein, we leave no *air*, nor do we fill the whole Ball with *Mercury*, but pour in ſo much Water, as when the *vacuum*, is made, and the *Mercury* ſunk down into the *Cilinder*, the Water ſwimming thereon may fill about half the Ball, that the Fiſhes may move, and bear themſelves thereon.

When we had a mind to put ſmall Animals therein, as little *Lizards*, or *Horſe-leeches*, or the like, we ſhut up with them a little Ball of Solid Glaſs, which following the *Mercury* in making the *Vacuum* ſtops the Mouth of the Cane E, and keeps the Animals in the Ball to be more commodiouſly obſerved.

Luertole. Mignatte *Fig.* 6.

All theſe Advertiſements may perhaps ſeem ſuperfluous to ſome; but thoſe who are converſant in Experiments, and know the difficulties they often meet with in making them, through the impediments and inconveniencies of a material *Apparatus*, will rather approve of, than ſlight theſe niceties, it being almoſt incredible to tell their uſe, and how great an expence of time may be ſaved by them.

An Experiment
Of Sounds in Vacuo.

Tab. 9. *Fig.* 4.

HHaving hung a ſmall Bell by the thread, inſtead of the combuſtible Ball in the former *Experiment*, and making the *vacuum*, we began to ſhake the Ball forcibly, and the Bell gave the ſame Tone as if the Ball had been full of common *Air*; or if there was any Difference it was too little to be perceived; indeed, in this *Experiment* the ſonorous *Inſtru-*

ment

ment (tho the thing is impracticable) ought to have no communication with the Veſſel, otherwiſe we cannot certainly affirm, whether the Sound proceeds from the Rarified *air*, and *Effluvia* of the *Mercury* in *Vacuo*, or from the Vibration communicated by means of the Thread from the percuſſion of the Metal to the Glaſs, and ſo to the External *air* encompaſſing it.

Nevertheleſs, we thought of making this Experiment with a Wind Inſtrument, becauſe it receives its trembling, not from Percuſſion as a Bell, but from the Impetus of the *Air* ruſhing out of it. And becauſe it might be too hard a Task, if not impoſſible, to place ſuch an Inſtrument in a *Vacuum* made with *Mercury*, we reſolved to encloſe it in a Veſſel exhauſted of its *air* by Attraction, ſo as it has been lately practiſed by Mr. *Boile*, with admirable ſucceſs, in thoſe his curious and noble Experiments; among which, this was thought of alſo, though it was not put in Practice for want of a fit Artificer to make the *Apparatus*. Now tho the Veſſel can never be emptied ſo perfectly by that way, as by *Mercury*; yet the *air* is always ſo far Rarified, as from the manifeſt difference which appears in thoſe Effects that depend really upon the ordinary Natural *Preſſure* of the *Air* upon them, we may eaſily come to form a right Judgment what they would be in a perfect *Vacuum*. We will here truly relate, what we happened to obſerve; confeſſing, that it is more to ſhew the manner and Method we thought of to make the *Experiment*, than for any certainty we were able to gain thereby: ſince it may be ſaid, we rather failed, than made the *Experiment*.

For this purpoſe we made a little Organ, as ABCD of but one Pipe, and with the Bellows having *Communication* with the Pipe by an hollow Conveyance in the *Baſis* B C. This *Organ* we included in the *Braſs Box* F, and put the *handle* H I through the Mouth G of this *Box*. This handle we reſted upon the Pillar, or Prop K L, when we had firſt put it through the Ring M, ſodered to a ſmall Iron Rod paſſing each way through the boards of the Bellows, and faſt-

Tab. 10. *Fig.* 7.

Fig. 8.

ned to them, ſo that by moving the *handle* this way, and that way, either the one, or the other was opened and ſhut, forcing the *air* into the *Pipe*. Then taking a Piece of ſoft Leather, and making an hole in it, we put it over the Handle, binding it faſt upon the Mouth G, and likewiſe gathering it together, we tyed it about the Handle (as in the *Fig.*) ſo that all Ingreſs of the *air* might be prevented; and through the pliantneſs of the Leather, the handle eaſily moved every way. All being ſo prepared, and the Cover E Cemented on very cloſe; we began to exhauſt the *air* out of the Box with a *Pump* ſcrewed on to a *Hole* in the Cover N, and at every Draught turning the Stop-cock O, that when the ſucker was forced down to drive out the attracted *air* at the *valve*, and Noſe P, the *air* might not re-enter into the Box F, and fruſtrate the Labour of the *Operator*. After many draughts, that the *air* became ſo rerified, as the Leather which cloſed the Mouth G was quite drawn in, and the Force of a very ſtrong Man was unable to draw back the Sucker, or Plug; we began to move this way, and that way, the Handle ſo to convey the *Subtile air* out of the Bellows, into the *Organ-pipe*, and liſtned to the *Sound*. But the Truth is, we could not perceive it to differ at all (not onely) from that which was made in the ſame Box, when ſhut up full of *air* in its *natural ſtate*, but (alſo) not ſenſibly from that made in the Box, when we had, by the *Pump* forced and condenſed a great quantity of *air* therein: Wherefore (ſome did ſay jeſtingly, either that) the *air* has nothing to do in the Production of *Sounds*, or is able to do it alike in *any ſtate*.

Tab. 10. *Fig.* 9.

An

An Experiment,

Of the Operation *of the* Magnet *in* Vacuo.

HAnging a *Needle* by the Thread by which the *Bell* was faſtned before, we applyed a *Magnet* to the outſide of the Ball, and found it was attracted at the ſame *diſtance* as when the Veſſel was full of *air*. *Tab.* 9. *Fig.* 4.

An Experiment

Of the raiſing of Fluids *in ſmall* hollow Canes *in* Vacuo.

AMongſt other *Effects* of the *Airs Preſſure*, ſome have reckon'd that of almoſt all *Fluids* riſing up in ſmall Canes therein immerſed; believing, that the ſmall *Cilinder* of *air* preſſing through the little Cane upon (any fluid ſuppoſe) the Water, acts more faintly, by reaſon 'tis leſſened or ſtraitned by the great Adhæſion of the Fluid to the inſide of ſo ſmall a Veſſel: as on the contrary they judge, that the *air* which freely preſſes upon the large *Superficies* of the Fluid round the out-ſide of the ſame Cane, being permitted to bear upon it with its whole force; raiſes it therein, until the *Momentum* of the Water raiſed, together with that little *Preſſure* within the Cane, counterpoize that of the *external air*. To have ſome light as to the Truth of this *Diſcourſe*, we attempted to ſee what the *Effect* would be in *Vacuo*.

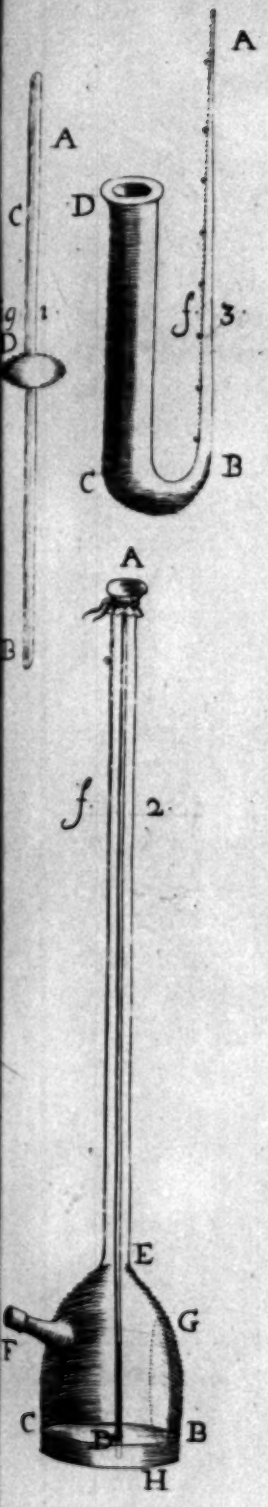
We

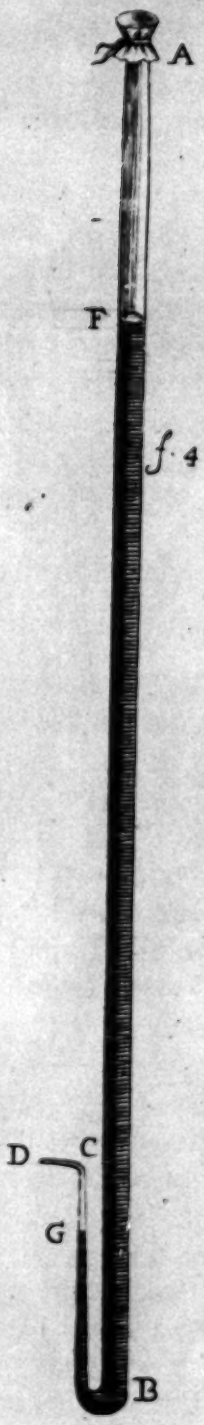
We therefore prepared the former Ball as was directed for Fish, (*Tab.* 10. *Fig.* 1.) that is, by filling the upper half with Water, into this we immersed the small Cane A B (repre-
Tab. 11. *Fig.* 1. sented in the Table of its full bigness) which was open at each end, and had Cemented upon it in the middle an hollow Button of *Glass*, counterpoised to keep the Cane upright in the *Water*; Then closing the Mouth of our large Ball A C,
Tab. 10. *Fig.* 1. we made the *Vacuum*, the Water standing to the midst of the Ball: and the small Cane stood Erect, by reason of its hol-
Tab. 11. *Fig.* 1. low Button, and the Water rose in it up to C; then the lower Mouth being stop'd with a Finger, that the *air* entring
Tab. 10. *Fig.* 1. might not empty our larger Vessel, we unbound it above, and opened the Mouth A C, to see if (the *air* being admitted to press upon the Water) that greater and more violent impulse would cause any *alteration* in the Level C of the small immersed Cane; but it did not.

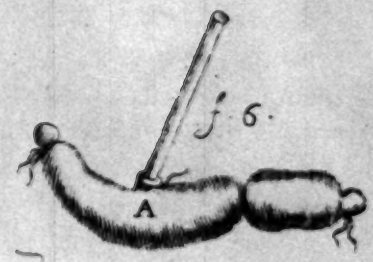
After this *Experiment*, 'twas yet doubted, that the wet received by the whole Internal *Superficies* of the little Cane, when quite Immersed in the Water, before the *Vacuum* was
Tab. 11. *Fig.* 1. made, might serve like Glew to detain the small *Cilinder* of Water C D whereto it might be kept by *Adhesion* also, as well as it was before by the force of the *External Pressure*: wherefore it was resolved, first to rarifie the *air* in the Vessel which we intended to try the *Experiment* in; that the first Immersion of the Cane might be made with the *air* already *dilated*, and *rarified*, and with the inside of the Cane *dry*, that there might be nothing in it to raise more *Water* than that which the weak *Pressure* of that *thin air* was able to do: and that afterwards reducing the *air* to its *natural* state, and then Artificially compressing it; it was thought we might discover some observable *variation* in the height of the Water contained in the *Cane*.

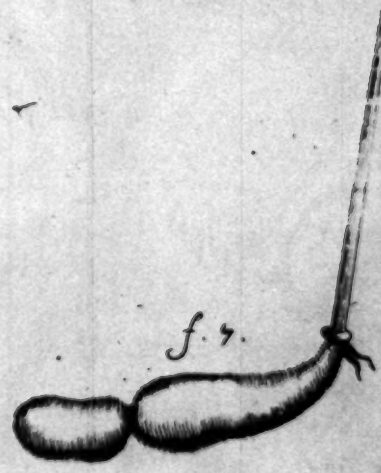
Tab. 11. *Fig.* 2. We therefore took the Vessel A B C made of thick Glass, into this we let down the small Cane A D and closed the Vessel at A with a *Bladder*; then we laid the Vessel with the Neck A E, and the included Cane A D *Horizontal*, and poured in *red Wine* (the better to discern the *Level* in the Cane)

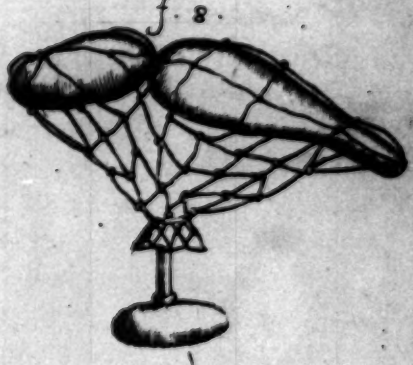
Tab. II. p. 54.











Cane) by the Mouth F, till it came to the Mark G, H: taking Care (in pouring it in) that the mouth of the Cane D was not wetted; this done, we ſcrewed on the Noſe of a *Pump* into the *female Screw* before ſodered on to the Mouth F, and made ſeveral ſtrong Attractions: after this we ſet the Veſſel upright, and the Wine ſtood at the Level BC, the Mouth of the Cane D being *immerſed* therein: through this then the *Wine* was immediately raiſed up toward E, equal to what it would have been in *air naturally* compreſſed; for not onely when by opening the Mouth F, we ſuffered the *air* to return to its *natural* ſtate, but when we condenſed it very much with the Pump, we could not perceive the Wine riſe at all above the firſt *height*, to which the *rarified air* had mounted it.

There was alſo made another *Experiment*, which was this; Within the Ball ſo often made uſe of, we placed the *Syphon* ABCD, ſo hung, that when the *vacuum* was made, it might remain upright in the midſt of the Ball, and full of *Mercury*; we then obſerved, to what Degree the *Mercury* roſe in the ſmaller Leg AB, and then upon admiſſion of the *air* could obſerve no alteration. This *Experiment* was often repeated, always with the ſame ſucceſs. *Tab.* 11. *Fig.* 3.

Laſtly, They that took the raiſing of Fluids to a *determinate* height, to be an undoubted Effect of the *Airs Preſſure*, were deſirous to ſee, if the *air* (which preſſes upon the Stagnant Level) when forced to paſs through the hole of a very ſmall Cane, and muſt neceſſarily do ſo to exert any *Preſſure*, comes thereby to be ſo weakned and leſſened, that any obſervable *alteration* follows in the height of the Fluid ſo preſſed: which they thought would probably happen; becauſe if one *Momentum* were weakned, the other muſt certainly preponderate, and ſo alter the firſt *Æquilibrium*.

To this End, there was taken the Cane ABCD, whoſe height AB was 46 Inches, and the *Return* BC 11 ½ Inches, drawn to a greater Degree of ſmallneſs than is *repreſented in the Figure*: this being open at A, and D, was filled with *Mercury* at the Mouth A, till it came to D, the Mouth of the *Return*, *Tab.* 11. *Fig.* 4. 2 *Brac.* ½ *di Br.*

Return which we then ſealed at the Flame of a Candle, and compleated the filling of the Cane to A, and tyed it over faſt with a Bladder; then we broke off the End D, and the *Mercury* began to run out very ſlowly, contrary to what we have obſerved, when the *air* purſued it at the other end; whereas, inſtead of *air*, the Cane had now a *vacuity*, which increaſed gradually from A, ſo that the *Mercury* was no otherwiſe forced out, but by the weight of that which was above 1 *Brac.* ½ 28 $\frac{6}{10}$, reckoning from C towards A: and it immediately ſtop'd when it came to F the very ſame height above C, as the *Mercury* was off in another *Tube* immerſed in a large Veſſel at the ſame time. After this, holding the Cane *Perpendicular* to the *Horizon*, by lifting it gently up and down, we cauſed a Motion in the *Mercury*, ſo that by the *Vibration* of it backward and forward, in the two Arms of the Veſſel, there ran out at each *Vibration* a little *Mercury* at the Beak D; ſo that when the Cane and *Mercury* were at reſt, there remained a ſmall part of the little Cane, empty of *Mercury* GCD. So the *Air* preſſing upon G, tho ſtrained through ſo narrow a paſſage as D, yet had not loſt ſo much of its force, as to cauſe any ſenſible *abatement* of the Height of the *Cilinder* F C.

From all theſe Experiments, and ſome other of a like *Nature*, which we have now no time to relate, ſome thought they ſaw good grounds to Affirm, that *That* Opinion of a more Languid *Preſſure* made by the *air* through ſo narrow *conveyances*, taken abſolutely ſo, is not ſufficient to produce *this*, and the like *Effects*; but they believed, That there muſt be at leaſt allowed ſome other *concurrent* Cauſe.

An

An Experiment
Of Water *in* Vacuo.

THat Noble *Obſervation* of Mr. *Boiles*, of the boiling of warm *Water* in *Vacuo*, made us above meaſure curious, not onely to ſee ſo rare, and ſurprizing an Effect, but alſo gave us an *hint*, and deſire to try the ſame *Experiment* with *ſimple water*, and alſo with Water brought to as great a Degree of *Cold*, as it is capable of; without *Freezing*.

There was put into the Veſſel (repreſented by *Fig.* 5. *Tab.* 10.) a quantity of *natural water*, unaltered from its ordinary temperament: in this, after the *Vacuum* was made, there appeared a *ſhower* of ſmall drops, which tho they were in great Plenty, yet came very ſlow, and the Water loſt nothing of its Tranſparency: their Motion was *upwards*, till the *Showr* gradually ceaſing, the Water became *ſedate*, and *quiet* as at Firſt.

The *warm Water*, as ſoon as ever the *Vacuum* was made began violently to boil up toward the top of the Veſſel, with a noiſe not unlike that made by a *Cauldron* boiling very faſt; but upon opening the Ball, and taking out the included Veſſel, we could not obſerve any *heat* acquired by this *Ebullition*.

The *chilled water* threw up four, or five ſmall Bubbles, and then reſted, without any other ſenſible Change, or Alteration.

Note, that upon the admiſſion of the *Air*, the ſhower of ſmall Drops ceaſed immediately in that *Water* of a *natural Temperament*; as likewiſe the boiling of the *warm water*.

An Experiment,

Of Snow *in* Vacuo.

AT firſt we put in a ſmall piece of *Snow*, of which upon the fall of the *Mercury* there ſcarce appeared other than the *melted* Water. This ſo haſty *diſſolution* thereof ſeemed *ſtrange* to us; wherefore to make the *Experiment* more *clear*, we repeated it with a larger piece made ſomewhat *Cilindrical*, as long, and big as could be put into the Ball: which being filled with *Mercury*, we thruſt the *Cilinder* of *Snow* into it. But ſlipping out of his hand that immerſed it, and ſo ſwimming upon the *Mercury*, we might perceive that in the very act of *Immerſion*, the *Mercury* had preyed upon, and eaten off a good part thereof; and the diſſolved Water ſwam upon the *Mercury*. So we concluded, that it was the *Mercury* which melted the firſt ſmall piece of *Snow* ſo ſuddenly, and not the *Vacuum*, as at the firſt view it ſeemed to be; wherefore putting the *Snow* in again, cloſing the Veſſel, and making the *Vacuum*, the little that remained, was as ſlow in Diſſolving, as it uſed to be in the *air*.

This *Experiment* was made in the *Summer*, ſo that the *Snow* was not in Flakes (*Solla, we call the Snow at* Florence, *when it falls like Down, before it is frozen together*;) but ſome of that taken out of the *Conſervatory* where it was trodden down, and preſſed together.

An

An Experiment

Of the Diſſolution *of* Pearl, *and* Coral *in* Vacuo.

THis *Experiment* we owe likewiſe to Mr. *Boile*, which was after this manner.

Pearles, and *Coral* (as is well known) are diſſolved in *Vinegar*. Tho this *Action* proceeds very ſlowly in the open *air*, and conſiſts in the curious diſcharging of very ſmall Bubbles, which riſe from Bodies of the *Pearl*, and *Coral* themſelves: yet they do not Riſe ſo thick, as to hinder the *Tranſparency* of the *Vinegar*; eſpecially, from the *Coral*, which if not finely powdered, is much ſlower in Diſſolving: but *Pearls* being ſofter, afford a greater plenty of *Bubbles*. We deſired to ſee each of them ſeverally in *Vacuo*; and obſerved ſo great a quantity of Bubbles to ariſe from each; that the *Vinegar* was raiſed all in *froth*, and run over the Veſſel, which therefore ſhewed as if it had been full of *Milk*, or pure *Snow*: Then we gave admiſſion to the *Air*, whereby the *froth* was immediately ſunk, and the *Vinegar* with its Natural *Tranſparency* began to act as before.

We will not omit here an *Effect* accidentally obſerved in this *Diſſolution*, which was this: The *Pearls* when they ſink to the bottom, gather into one, or more little bubbles of *Air*, which naturally riſing up, carry the *Pearl* with them: but as ſoon as ever the Bubbles riſe above the *Vinegar*, and by the chock of the *Air* break,

their Covering is curiouſly ſcattered about. Then the *Pearl* ſink down again, and at the ſame time other parts thereof gathering into new *Bubbles*, raiſe themſelves. And ſo all the while the *Ebullition*, or *Fermentation* laſts, there is a continual Motion of them up and down through the *Vinegar*.

A RELATION OF *VARIOUS ACCIDENTS*, Obſervable in ſome ANIMALS Included in *Vacuo*.

FRom the very time *Torricelli* found out his Firſt Experiment of *Mercury*, he had thoughts of including ſeveral *Animals* in the void ſpace, to make Remarks upon their *Motion*, *Flight*, *Breathing*, and all other obſervable *Accidents*: But not being then provided with fit Inſtruments for this purpoſe, he was contented to perform what he was able to do: for ſmall, and tender *Animals* oppreſſed by the *Mercury*, under which of neceſſity they muſt lye, to be at the top of the Veſſel when inverted and immerſed in the Stagnant *Mercury*, would be moſt commonly dead, or expiring; ſo that it would be hard to determine, whether they had received more damage from the *Suffocation* of the *Mercury*, or from the want of *Air*. And either for this cauſe he forbore, or was deterred from attempting the *Experiment* in an open Veſſel, miſdoubting the ſufficiency of the Ligature to ſuſtain the *air*, bearing thereon with its whole Weight: and beſides, he was diverted ſoon after this *Invention* by other *Employments* which wholly took him up, that he had no time to apply himſelf to this, and give it a greater *perfection*, which it is probable he would have done, if a too haſty *Death* had not prevented him. But we being ſatisfied, that the

the force of the *Air* was not ſo great that the *Cement*, and a *Bladder* well tyed down, was unable to withſtand it; have always *ſucceſsfully* made uſe of a Veſſel open at both ends, as already hath been ſhewn, and as we have alſo done in theſe. Wherefore, we will now proceed to give an account of the *Accidents* obſerved in divers *Animals* included in this Veſſel; as follows.

Mignatta An *Horſe-leech* being kept in *vacuo* above an hour remained alive, and well; freely moving her ſelf, as if ſhe had been in the *Air*.

Lumaca. The ſame did a *Snail*; in both theſe, tho deprived of the *Air* we could obſerve nothing to argue it had any Effect upon them.

Grilli. Two *Graſs-hoppers* were for a quarter of an hour very lively, continually moving up, and down, but not leaping: upon the admiſſion of the *air* they leaped away.

Farfalla. A *Butterfly*, whether hurt by the hand in putting it into the Veſſel, or whether it ſuffered from the want of *air*, 'tis certain, that as ſoon as the *vacuum* was made, ſhe was quite deprived of Motion, except a ſcarce diſcernable, and languid Tremour in her Wings, which upon the Ingreſs of the *air* ſhoke very much; but we could not diſcover well, whether the *Animal* it ſelf, or the Motion of the *air* cauſed it; but upon taking out of the Veſſel, we found it dead.

Moſcone. There are a ſort of *Flyes* larger than ordinary, commonly called *Moſcone* in *Italian*, that make a great *Buzzing* through the *air* with their Wings: one of theſe (which being ſhut up in the Veſſel, continued to buz very vigorouſly) as ſoon as ever the *vacuum* was made, fell down as if it had been *dead*: and the *noiſe* of its wings ceaſed; we preſently gave it *air*, whereupon it moved a little, but the Remedy was too late; for it was ſcarce taken out before it died.

Lucertola A *Lizard* in *vacuo* quickly grew ſick, and ſoon after cloſing her Eyes, ſeemed to be dead: but we agreed afterward, that we obſerved ſome *Reſpiration*, perceiving a little ſwelling in the *Thorax*, between the Fore-legs: we continued the

the Confinement for the ſpace of *ſix Minutes*, in which time it had loſt all breathing, and appeared Dead: we then admitted the *air*, which ſo recovered it, that preſently the Veſſel being opened, ſhe leaped out, and ran away; catching it again, we included it the ſecond time, and ſhe appeared ſick, as before; but the *air* revived her again: we Impriſoned her the Third time, and in *Ten Minutes* after ſome ſtrainings, as if poyſoned, ſhe vomited, and fell down quite dead in the Glaſs.

Another little *Lizard* in leſs time ſuffered the ſame *ſtrainings*, or Convulſions; and then had a little Reſt, and as if ſhe had taken *breath*, and gotten *ſtrength* thereby, ſhe endeavoured ſeveral times to creep up the ſides of the Veſſel; when the ſame *Convulſions* returned with ſtrange *Diſtortions* of the Mouth, and ſwelling of the *Eyes*, as if they would have ſtarted out of her Head; ſhe turned upon her Back, and after a little gaping for breath, dyed. It was after obſerved, that ſhe had diſcharged ſomething by the *Mouth*, and *Anus*; whence the Belly became flaccid and empty.

Another beginning to ſuffer the ſame *torments*, had immediate *Relief* from the *Air*.

A *ſmall Bird*, as ſoon as the *vacuum* was made, began to gape, and pant for breath; and ſhaking its Head, hung down its Wings, and Tail; after half a Minute, when it ſeemed almoſt dead, we gave it *air*, and ſo at firſt it ſeemed to revive, but in few *moments* ſhutting the Eyes, it dyed. *Uccelletto.*

A *Gold-finch*, and after that another, though preſently ſuccoured with the *air*, yet found it too late. So ſudden is the *irreparable* hurt theſe tender *Animals* receive from the *privation* thereof. *Calderugio.*

The almoſt Inſtantaneous Death of theſe Birds, may at firſt view ſeem to contradict an *Experiment* of Mr. *Boyles*, wherein he mentions a *Larks* living in the Evacuated *Receiver*, though one of its *Wings* was hurt, about *Ten Minutes*. And a *Sparrow* taken with Bird-lime endured for *Seven Minutes*; at the end of which, ſeeming dead, ſhe was recovered. *Allodola.* *Paſſera.*

recovered with the *freſh air*: and being again included, and the Veſſel *Evacuated*, in the ſpace of *Five Minutes* dyed. But whoever Reflects upon the different ways of making the *Vacuum* in the one, and the other Inſtrument, will confeſs that the two *Experiments*, how different ſoever they ſeem; do indeed wonderfully agree: for whereas in that, the *air* is thinned by repeated Attractions, and ſlow, and little more then inſenſible acquiſts at each *draught*: in our *Inſtrument*, 'tis reduced to the greateſt degree of *Rarity* by the Inſtantaneous fall of the *Mercury*; to which, when the *air* is brought, 'tis no longer ſerviceable to their *Reſpiration*. And if (when we had included the *Animals*) we inclined the upper Mouth
1 *Brac.* ½ of our Veſſel below the *perpendicular* Height of 28 $\frac{6}{12}$ Inches reckon'd from the Level of the Stagnant *Mercury* in the Baſin, and opening the lower Mouth, we gradually raiſed it by little, and little to an upright; we have obſerved the very ſame Effects, related by Mr. *Boyle*; the *air* then of neceſſity paſſing through all the intermediate degrees of *Rarefaction*, from a greater to a greater (as it does in Evacuating his *Receiver*) is not ſo ſoon rendered uſeleſs to the *Reſpiration* of theſe *Animals*.

Granchio. Tenero. A *ſoft Crab* at firſt putting in, moved; then grew feeble, and began to faint away; when he had ſtood a little while motionleſs, or rather with all his *Members* contracted, we gave him *air*, whereat he ſeemed revived, and began to move ſlowly; but taken out of the Veſſel, ſoon dyed.

Ranocchio. A *Frog* was preſently giddy, and notably ſwell'd all over; but when the *freſh air* came in, with a ſudden leap, he ſhewed himſelf recovered.

Granchio duro. We incloſed at another time, in the ſame Veſſel, an *hard Crab*, and a *Frog* together, the *Crab* ſeemed to move, till the end of the *Experiment*, which was a full half hour without any, alteration, except perhaps a little ſwelling.

Ranocchio. The *Frog* in ten Minutes was unmeaſurably puft up in every part, and two great Bladders appeared on the ſides of his *Jaws*, and vomiting up a great quantity of *froth* at his Mouth (which ſtood wide open, filled with his *Tongue*, and all

all the *membranes* disformedly ſwelled, and blown up) in this poſture he remained Motionleſs: at the *entrance* of the *air* the ſwellings fell at once, and he appeared quite changed, being extream lank, and thin; ſo that we thought him much leſs than when he was firſt put into the Veſſel; when we took him out, he was Dead. The *Crab* as we ſaid before, was alive, but in few Minutes *dyed*.

Another *Frog*, much ſwell'd as the former, caſt up a great deal of *Froth*, and other things at the Mouth: and in *half an hour* was found quite dead. At the Entrance of the *air* he appeared ſhrunk up, and lank as the other. The *Thorax* was opened by an Acurate *Anatomiſt*, who at firſt could not find the *Lungs*, they were ſo ſhrunk up together for want of the *air*: but by blowing with a Straw in at the *Ductus* by which they breathe under their *Tongue*, (they were *rediſtended*; whence it was viſible, the moſt part of the *air* which was contained in the *Animal* when firſt included, was got out to enjoy a larger Field in the *Evacuated* ſpace, without tearing, or hurting any of the Veſſels; for upon blowing they were all tight, and ſwelled up.

Several *ſmall Fiſhes* which were very lively, were included with a ſufficient quantity of Water; and as ſoon as the *vacuum* was made, they were remarkably ſwell'd, and fainting turned up their Bellies. They endeavoured ſeveral times to keep their *backs upwards*; but they ſtill turned again: when the Veſſel was opened, they ſunk to the *bottom*, where unable to recover, they dyed. We preſently Diſſected one of them, and compared it with another taken alive, which had not been in a *vacuum*; and examining the *Intrailes*, we found the little *air Bladder* empty in this; whereas in the other, it was round and full, as is uſual in all Fiſh. *Peſcetti.*

In a pretty large *Barbel* the Eyes were much ſwell'd; the Fiſh turned on his back, ſtretching out the *Finns*, as if they had been ſtiff and frozen, with the *Gills* opened wide, and the whole Body diſtended with *wind*, and ſo it lay at the top of the *water*. It attempted by ſeveral *jerks* to turn *Barbio.*

to its *natural* Posture, but in vain. After *six Minutes*, upon the return of the *air*, the swelling of the Eyes assuaged; and tho the *Thorax* returned to its due *proportion*, yet it was forced to keep at the bottom continually *gaping*, and unable to raise it self in the Water; and being put into *fresh*, it soon dyed: being opened, we found the Bladder all shrunken, when that of another *Fish* (dissected alive, tho five times less than this) was yet much larger, and turgid.

Anguilla. An *Eele* stayed a long time without *fainting*, or any *diminution* of its *vivacity*: but at last in an hour that dyed also; and being opened, the *bladder* was empty, as they of the other *Fish* were.

Barbio. Another *Barbel* having been in *vacuo*, and refresh'd again with the *air*; by great chance was taken out alive: wherefore we gave him his *liberty* in a *Cistern* where others were kept, being above 34 Inches *deep*. This *Fish*, whether it was easier for him, or whether he was necessitated so to do by the emptiness of his *bladder*; 'tis certain, for the whole time he lived, which was about a Month, (altho we chased him about, and frightned him, by stiring the Water) he was never seen to raise himself, as the other *Fishes* did; but still left a Mark behind him on the *bottom*, sweeping it with his *belly*: his *bladder*, when dead, to sight was swell'd with Wind as it is Naturally, but was very much softer to the touch, than those of other *Fish* are.

1 Brac. $\frac{1}{2}$

Observations upon the Bladders *of Fish in* Vacuo.

THe *Bladder* of a great *Fish* swell'd with Wind, as it was taken out, being put in *vacuo*, shewed no alteration there: wherefore we opened the Vessel, believing that nothing else could vary the *Experiment*, except the Coats of the *bladder* were of too strong a *Texture* to be burst by the force of the *air* Naturally included therein: but upon the first

firſt Ingreſs of the *Air*, the Bladder appeared neither more nor leſs full than we had obſerved it in *Fiſh* killed in *vacuo*; a clear ſign, that the greater part of the *Air* in the *bladder*, by forcing, or taring the *Swim*, gets out through ſome inviſible Paſſages; and any little *Portion* that remains, by the increaſe which it receives in *vacuo*, ſerves to keep the *bladder* diſtended as at firſt.

Then being deſirous to find, where the *air* gets out of theſe Bladders, if by any *Ductus* naturally there, or made by the force of the *air*; we took, with the greateſt care poſſible, the *bladder* out of another *Fiſh*, and tyed the two Ends with a Silk, ſuppoſing, if there were any *paſſage*, it muſt be at one of them: this in *vacuo* appeared full, as the other had done; but upon the Ingreſs of the *air*, it ſhrunk up after the ſame manner: wherefore, to find the *Paſſage* where the included *air* breaks away, we made a ſmall hole, to put in a little Glaſs Cane, and bound the *bladder* faſt about it, (the *extremities* being yet tyed) and blew Wind into it through the *Cane*; which being in great plenty, ſwell'd the *bladder*; but at the ſame time, we perceiv'd it got out of a ſmall crack at A, (which muſt be that, where the *air* in *vacuo* found a vent) to which, holding a lighted *candle*, we might perceive the *flame* to wave; and viewing it attentively, when diſtended, it was not ſo ſmall, but it might be diſcerned with the *naked Eye*. *Tab.* 11. *Fig.* 6.

Having thus found, that the *air* did not get out at the Ligatures made, whilſt to free it ſelf, it was forced to make a new *crack*, we had a mind to ſee if it gets out after the ſame manner in the *bodies* of *Fiſhes* kill'd in *vacuo*; that is, by breaking the thin Membrane of the *bladder*, or by finding ſome hidden *paſſage*: wherefore taking carefully the *bladder* out of a *Roach* that dyed in *vacuo*, we made a hole in the *ſmaller* end, and put a *cane* in, as before, and blew very ſtrongly, but it held tight: an evident proof, that the *air* without breaking it, has ſome *vent*, which the weakneſs of our *Eyes* could not diſcover. *Tab.* 11. *Fig.* 7. *Laſca.*

We then thought of making the *Experiment* under *Wa-*

Tab. 11. *Fig.* 8. *ter*, which perhaps might detect ſomething to us: ſo we took the *bladder* out of the *Fiſh* alive, and well tying it in a *Net*, faſtened a convenient *weight*, and ſunk it in *water*, and then made the *vacuum*, when we might ſee many ſmall *bubbles* of *air* iſſue from the *ſlender* part thereof; where 'tis probable, the *Natural Meatus* is, which tranſmits it; when the Veſſel was opened, the *air* ſhrunk it like the other.

Laſtly, willing to ſee what way the *air* takes from the *bladder* to get out of the *Fiſhes* Body, whether by the *Laſca.* Gills, or Mouth; we covered a *Roach* with the ſame *Net*, that by affixing a *Weight* it might be kept under *water*; the *vacuum* being made, we ſaw a great deal of *air* come out of his Mouth in large *bubbles*, as before from the ſubmerſed *bladder*.

Here ſhould have been the End of theſe *Experiments*; but while theſe Sheets were in the *Preſs*; one of our *Academy* having thought of a way to *facilitate* very much the management of our Veſſel to make the *vacuum*, we will not omit to ſet it down here; and the rather, becauſe we found it indeed very convenient. The Invention conſiſts in joyning to the Cane B E (*Tab.* 10. *Fig.* 1.) the *Retum* B F G (deſigned in the *Figure* by the Prick'd Line) for putting as uſual the *Mercury* in at the Mouth A C, when it comes up to G; in the *Return*, we tye it down cloſe, and fill it up to A C, where being cloſed after the *uſual* manner, it is ſufficient to open the Mouth G, and without any *immerſion*, all the *Mercury* above 28 $\frac{6}{10}$ In- *1 Br.* $\frac{1}{4}$ ches taken from G towards E, runs out: and Note, that the Ball F G ſerves to keep in the *Mercury* in the fluctuating Motions it makes in the Two Branches of the Cane, (before it reſts) cauſed by the *impetus* of its fall.

This is all at preſent touching the Natural Preſſure of the Air, *and its Various* Effects.

Experiments

EXPERIMENTS
OF
Artificial Freezing.

AMong the reſt of the ſtupendious Works of *Nature*, that admirable *Power* has been always much regarded, whereby ſhe binds the ſlippery *Waves*, changing their fleeting *Inconſtancy* into *Solidity* and *hardneſs*. This *Effect*, tho daily before our Eyes, in compariſon of others more ſecret and rare; yet has continually afforded Ample Subjects of Curious *Speculation* to the Mind of *Man*: for, whereas *Fire*, when diſingaged in ſwiftly winged *ſparks*, by inſinuating it ſelf through the cloſe Pores of *Fluity* and *Metalline* Bodies; opens, melts, and reduces them to a perfect *Fluid*: ſo *Cold* on the contrary (a much ſtranger thing) ſtops and conſolidates the moſt Fluid *Liquors*, changing them into downy *Snow*, and glaſſie *Ice*; which upon the leaſt *Ray*, or warm *breath*, break Priſon, and ſteal away in their firſt *fluidity* again. And (which is yet more amazing) ſo violent a force of *Cold* in *Freezing*, is obſerved penetrating not onely *Glaſs*, but even the ſecret Pores of *Metals*. As in the Subterranean *Caverns*, and deep *Mines*, the Raging *Flames* impetuouſly divide, and in fury open all thoſe dark Paſſages; ſo *Cold* in the Act of Freezing, cracks ſhut Veſſels of thick and ſtrong *Glaſs*; ſtretches, diſtends, and at laſt, tears thoſe of pure *Gold*, and burſts aſunder thoſe of Caſt *Braſs*; and of ſuch thickneſs, as to break them by dead *weight* would require perchance, nay aſſuredly, ſome Thouſand *weight*: upon this ſtrange *Phenomenon* of *Freezing*, obſervable in *water* more than any other

other *Fluid*: Some have thought, that where the *Cold* operates in its proper *Laboratory* with fit *materials*, it reduces the pure Water to such a *temperament*, that it turns it into even the hardest *Rock-Cristal*, and *Gems* of various *Colours*, according to the different *Tinctures* received from the neighbouring *Mineral* steams; nay, even into the Invincible hardness of the *Diamond*. And *Plato* was of this Opinion, That *Diamonds* were Generated of the remains of those Waters whence in the secret *Caverns* of the Earth he thought *Gold* was produced; and therefore a *Diamond* is called, the *off-spring* of *Gold*, by that Divine *Philosopher* in *Timæo*.

But to return to the *Causes* of *Freezing*. The ingenious in all times have had various Sentiments thereof: whether it does indeed come from any *real* and proper *body* of *cold* (which in the *Schools* they call *Positive*) that (as *Light*, and *Heat* are Originally in the *Sun*) is either in the *Air*, or *Water*, or *Ice* it self; or any other part of the *Universe* as its proper place, and *Residence*, where it has its *Repository* and *Treasury*; in which sence the Words of the *Divine Oracle* in *Sacred Writ* may be taken. *Hast thou entered into the Treasures of the Snow, or hast thou seen the Treasures of the Hail?* Or whether *Cold* is nothing else but a Total *Privation*, or driving away of *Heat*. Touching this, and other curious Observations of the *Artifice* used by *Nature* in *Freezing* (whether she Atchieves her End by *Contracting*, or *Rarefying* the *Fluid*; whether the *Change* proceeds *slowly*, or *instantaneously*, &c.) we were induced to try several *Experiments* of *Artificial Freezing*, made by the outward application of *Ice*, and *Salt*; fully perswaded, that the *operation* does not at all vary from the *procedure* of *Nature*, when by the pure and simple *cold* of the *Air* she Congeals *Water*.

Job 38. ver. 22.

What hitherto we have had the *good luck* to observe, upon so *vast* and *boundless* a *Subject*, capable of so great and endless *Observations*, will be offered to you in the following *Experiments*.

Ex-

Experiments

To know, if Water *dilates it ſelf in* Freezing.

IT was the thoughts of *Galileo*, That *Ice* was rather *Water Rareſied*, than *condenſed*; becauſe, (ſays he) *Condenſation* conſiſts in *Diminution* of *Bulk*, but *increaſe* of *weight*; and *Rareſaction* in the *increaſe* of *Lightneſs* and *Bulk* too; but *water* in *freezing* gains in *Bulk*, and *Ice* is lighter than *Water*, ſince it ſwims thereon, *&c.*

This being ſuppoſed, (which *Experience* will ſufficiently prove) we were curious to ſee what *water* would do when confined in a Veſſel where it had not the leaſt room to *dilate*, yet on all ſides being encompaſſed with *Ice* to *freeze* it; ſince we ſtill obſerved (agreeable to *Galileo*) that *water* as well *frozen* into great Mountains of *Ice*, as in the ſmalleſt pieces, and of what Figure ſoever, continually ſwims upon the Surface of other Water; a certain proof, that in the act of *freezing*, (the increaſing of the *Bulk* conſidered,) it grows lighter; whether it be by the *interpoſition* of ſmall and inſenſible *vacuities*, or *interſperſion* of Minute *Particles* of *air*, or the like *matter*, after the manner of little *blebs* in *Criſtal*, and *Glaſs*, (for ſuch they appear to the *Eye* through the body of the *Ice* when held up againſt the *Light*) in ſome places thicker, in others fewer; and if the *Ice* be broke into ſmall pieces under *Water*, they riſe up through the *Water* in great Numbers.

The

The First Experiment.

Tab. 12. *Fig.* 1. TAking a Veſſel of thin *Silver Plate*, with Two *Covers* to ſcrew on, ſuch as we uſe to cool our *Sherbet*, and other Drinks in *Summer*; we fill'd it with *fair water* cooled with *Ice*, and then ſet it to *freeze*: it was cooled firſt, leſt if it had been put into the Veſſel at all *rarefied* by *Heat*, upon the firſt *Refrigerating* it ſhould Contract, and by that means gain room to Dilate in afterwards in *freezing*. When 'twas thought the *Ice* outwardly applyed, had done its work, we took the Veſſel out, and opening the *firſt Cover* (which was Concave) we found the *ſecond Cover* crack'd, and covered over with a thin *cake* of *Ice*, cauſed by the Water forced thither, by the Rarefying of that within the Veſſel as it *froze*.

Neither can it be thought, that this *crack* was cauſed rather by *condenſation* of the *water* in *freezing*; which being conſtrained by the violent force of the *cold*, to withdraw it ſelf into a leſs ſpace, for the avoiding a *Vacuum*, gradually drew down the *Cover* as it retired, 'till at laſt, unable to ſtretch any farther, it crack'd. I ſay, this is improbable; for if ſo, we ſhould have found the *Cover* bent *inwards*, whereas it was forced *outwards*, and conſiderably raiſed from the flatneſs it had before, as was alſo the *Superficies* of the *Ice* in the Veſſel; moreover, the *Edges* of the Crack turned *outwards*: whence we gather, how great the *Impetus* muſt neceſſarily be, that cauſed it; and would have been much more conſiderable, if a larger proportion of *water* had been congealed; whereas, breaking the firſt *Cake*, we found almoſt all the Water *Fluid*.

The

Tab. 12. p. 72.

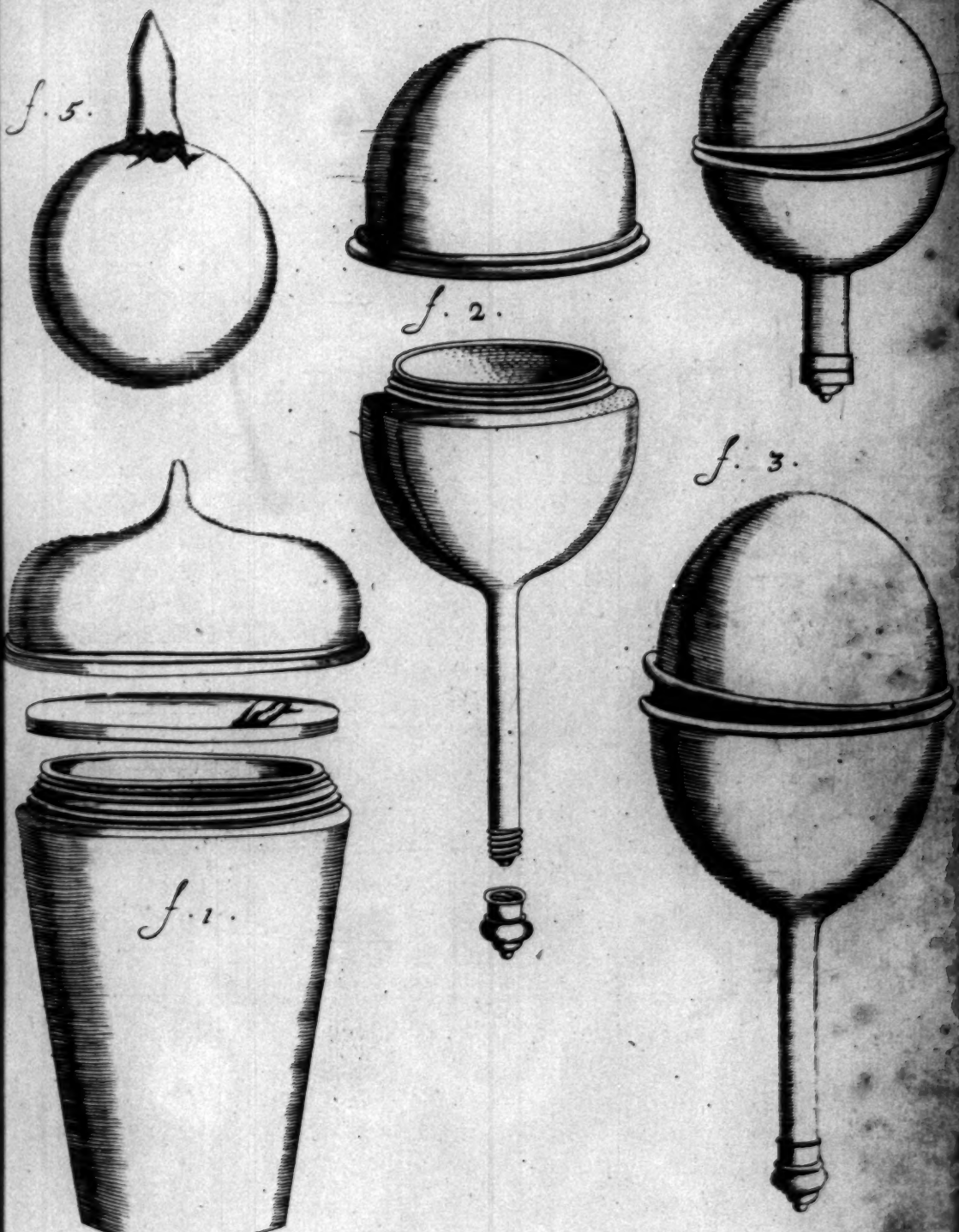
f. 4.

f. 5.

f. 2.

f. 3.

f. 1.



The Second Experiment.

FInding that the force of *freezing* far surpassed the *Resistance* of this our *First Instrument*; we thought of making a *Ball* of *Cast Silver* of the thickness of a *Crown piece*, and of an Oval Figure, to open in the middle with a *screw*, and with a *Top* screwed on at the End of the Neck, as in the Figure: Then shutting this Vessel, and screwing fast the middle screw with a Vice, we filled it with Water at the Neck, and screwed on the little Cover, and set it in a mixture of *Salt* and *Ice* to *Freeze*, and in a little while taking it out, we found it perfectly sound, and whole; opening it in the *middle*, we took out a *shell* of *Ice*, but it was very tender, and less Transparent than usual; and perchance more *dense* and close; for being put in Water, it did not seem to *buoy* up so well, but rather (as all thought) dived towards the *bottom*: in the midst was a *Cavity* as big as a large *Almond* without the Shell. This *Experiment* was repeated after by us, with the same *success*. *Tab.* 12. *Fig.* 2. 1 *Piastra*

The Third Experiment.

THere were some that wondered at this unexpected *accident*, seeming at first view to contradict, not onely the Opinion of *Galileo*, but what is more, to be *inconsistent* with it self; seeing tho this *Ice* appeared Condensed, and heavy, in respect of that made by the *cold* of the *air* without any *art*; yet it must necessarily be lighter than Water, because it in some measure still *swam* thereon: and so much the less could they satisfie themselves, as they saw the *vacuity*

always in the *middle* of the Water Congealed: whence it seemed necessary to conclude, That the Water, which *fluid*, sufficed to fill the *Ball*; being *frozen*, withdrew it self into so much a less *space* as the aforementioned *vacuity*; from so manifest an *inconvenience*, they were inclinable to think, there must be some *fallacy*, and therefore set themselves to observe very nicely the whole *progress* of the *Experiment*; So taking the Vessel very often out of the *freezing mixture*, and carefully viewing it on all *sides*, they perceived an almost insensible *boiling*, and bubling out at the middle Screw, from time to time; a manifest sign, that the Water (so great is the force of its *rarefaction*) crept through the *Spiral* Passages of the *Screw*; upon this, the *Screw* being waxed, and the *Ball* again filled, it was set in the *Ice* and *Salt* to *freeze*; and tho 'twas many times taken out, there was never observed any *bubbling*, or any *hissing* heard as before; but after the *freezing* was done, upon taking it out of the mixture, the Vessel was open on one side of the *middle Screw*, the rarefying power of *freezing* being great enough to force the *Screw*: The *Experiment* being often repeated, had still the same *Effect*; and being again tryed in a Ball of *Brass* with a Screw of twice as many *threads* as the *silver* one had, it still shewed the same *trick*.

The Fourth Experiment.

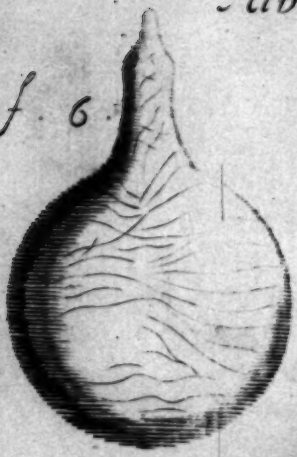
Tab. 12. *Fig.* 5. & 6. TO avoid this *inconvenience* of the *Screws*, we got some *Balls* made of *glass* half a *finger thick*, and filling them with Water, set them to *freeze*, being first sealed at the Flame of a Candle: The *Effect* was exactly the same as that of the *first* Vessel made of *Plate*; for they all were diversly broken, and split: some had their Necks quite thrown off; *others* through the unequal thickness of the *glass*, or irregularity of their Figure, were burst on one side; *others* were

Fig. 5. *Fig.* 6.

cracked

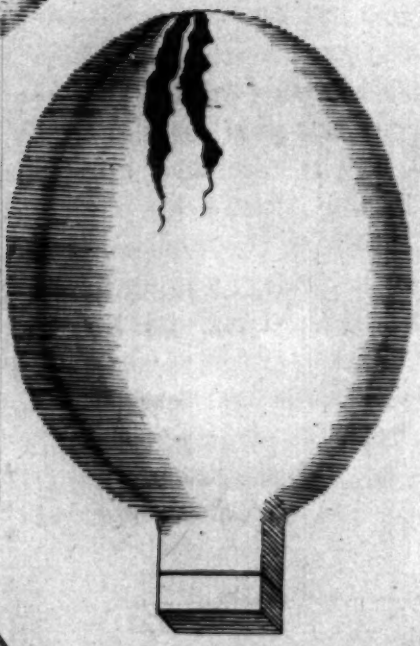
Tab. 13. p. 75.

f. 6.

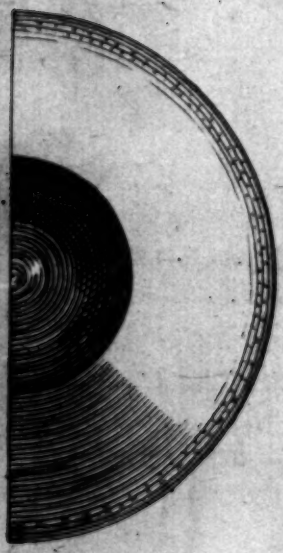


f. 1.

f. 1.



f. 4.



f. 2.

crack'd all over. And 'twas obſervable, that the *Neck* was generally broken off; when the whole *ball* was covered in the mixture of *Ice*, and *Salt*, ſo that the Water in the Neck being of the leaſt *bulk*, 'twas firſt frozen Solid there, and by that means ſtop'd, and forced the *Ball*: for in the procedure of the *freezing*, the remaining Water endeavouring every way, and either finding the *neck* the weakeſt part, or the *Ice* therein being as a *Cone*, or *Wedge* to ſplit it, it ſtill moſt eaſily brake through there; which never happened when the upper part of the *Ball* was left uncovered with the *freezing mixture*. How great the force of this *Rarefaction* was, may be gathered from this; that when the *Necks* were not turned downwards, upon the Veſſels burſting they flew off into the *air*, *five*, or *ſix* feet high, throwing up a great deal of the *Ice*, with which the *Balls* were covered.

The Fifth Experiment.

AT laſt we reſolved to caſt a Ball of *Braſs* all of one piece about Two *Crowns* thick, having but one Mouth at the *foot* thereof, ſo made as to be very cloſe ſhut with an exquiſite *Screw*. Then to take the *Lump* of *Ice* out whole, we made a ſmall *creaſe* round it, where by putting it again in the *Lare*, it might be cut in two in the midſt, which ſhewed a ſtrange *accident* in the Water; for this ſmall *inequality*, as little as it was, made the *Ball* burſt in that place. *Ottone* 2 *Piaſtre* *Tab.* 13. *Fig.* 1.

Whereupon we made another *Ball*, and without weakning it in any part, ſet it to *freeze*; but this was broken, as all the other (for we tryed it often) in that place which the *water* found moſt *defective*.

The Sixth Experiment.

Tab. 13. *Fig.* 2. THE Laſt *Experiment* was made with a *ball* of *fine Gold* of the *ſize* repreſented in the *Figure*: this having undergone many *freezings* without any viſible *crack*, cauſed at firſt no little *wonder*: and ſome began to doubt, whether, or no, the ſpace requiſite for the *freezing* by the *Diminution* of the *Thickneſs* of the *Metal*, by the force of the *Water*, and by reaſon of its ſoftneſs, might inſenſibly be compreſt, (as *Tin*, *Silver*, and *Gold* it ſelf, become more compact by being *hammered*:) but at laſt obſerving, that whereas the *Ball* before *freezing*, was *flatted* ſo, that it would ſtand upon the *bottom*; when it was taken out of the *freezing* mixture, it would not ſtand upright; every one was well ſatisfyed whence this happened: and becauſe it ſeemed to us perfectly *Spherical*, to be the better aſſured thereof, whether it would remain of its firſt *Size* (if it did not burſt in repeating the *Experiment*) or whether it would ſtretch *Ottone.* *bigger*; we made a *Ring* of *Braſs* exactly fitted to the Veſſels greateſt Circle. All along in the *freezing*, by *examining* it with this *Ring*, we ſtill found it grow *bigger*, and *bigger*; that pure *metal*, by reaſon of its *ſoftneſs* and *pliantneſs*, ſtill *dilating* and *ſtretching* it ſelf: and perhaps, if it had been made of *caſt Metal*, the *Effect* would have been more *conſpicuous*; but being made of Two *pieces*, it at laſt burſt at the place where it was ſodered with *Silver*, and the *Crack* beginning at the *Soder*, ran ſlanting down into the *Gold* alſo.

An

An Experiment,

To meaſure how great the force of Rarefaction *may be in* Water *ſhut up in cloſe Veſſels, to* Freeze.

TO obtain this, we thought of making a Metal Ball of *braſs*, like the former, but perfectly *round*, and according to our Eſtimation, ſo much thicker, that the force of *Rarefaction* ſhould be unable to break it; and filling it with *Water*, to ſet it to *freeze*, as before; the *Cover* being faſt ſcrewed down. *Ottone.*

This was *done*, and at firſt we found that the *Water* was *frozen* without any running out, or cracking the *Veſſel*: wherefore we put in the *Lare*, and (keeping it as near as poſſible of the ſame *Figure*) there was taken off every where a thin *coat* of *Metal*; and then 'twas ſet to *freeze* the ſecond time with *water*; and not being burſt alſo, altho it was *frozen*; we again turned off a thin skin from the Ball; this *Experiment* we repeated with three Balls, the thickeſt whereof is repreſented by the 4. *Fig.* which ſeemed to us the greateſt thickneſs the force of *Rarefaction* in *freezing* Water could over-power: having proceeded ſo far, we were deſirous to reduce this to the force of *dead weight*, and the moſt probable means we thought of, was to caſt a *Ring* of the ſame Metals and hardneſs, and exactly of the thickneſ of the Ball, turning the inſide *conical*, and fitting thereto an *Iron Cone*, ſo that the *Iron* might riſe about the breadth of the *Ring*, above the upper Edg thereof; being thus prepared, we thought of putting the *Ring* over an hole made in the midſt of a thick Stone *Table*, ſomething larger than the bore of the *Ring*; we then thought to proceed to *Tab.* 13. *Fig.* 4.

lay

lay on Weights upon the top of the *Iron Cone*; or at leaſt, force it down with Weights hung to an *hook* made at the lower End thereof, that ſo the force being *Perpendicular*, it might equally drive the *Iron* into the *Ring*, and then leaſurely adding ſmall *leaden* Weights, we might know the leaſt Weight capable of burſting the *Ring*: and to be ſecured, that the bearing of the *Ring* upon the roughneſs of the *Table* might be no hindrance to its breaking, we thought to faſten round the hole of the *Table*, a Plate of *Poliſht Steel*, and ſmooth the under-ſide of the *Ring*, that it might upon the leaſt touch ſlip upon the *Steel*: but becauſe an *immenſe* Weight was but ſufficient to Conquer ſo great a *Reſiſtance*, we thought to obtain our End, by making the *Experiment* with ſeveral much ſmaller *Rings*, but of different *Sizes*, and with more managable Weights; and ſo by examining the *Reſiſtance* of theſe *Rings*, and comparing the repeated Trials, to come near the knowledge of what would break the firſt *Ring*, of the ſame thickneſs of the Ball; and by conſequence, the force of *Rarefaction* in *Freezing*.

Theſe were our thoughts; but ſtill finding upon cutting our *Balls* that were crack'd in the *freezing*, ſeveral inequalities, and defects in the *founding*, proceeding either from the *wind*, or dregs of the *Metal*; when *infuſion*, we were diſcouraged from Proſecuting the *Experiment*, upon ſo many *uncertainties*; nevertheleſs, we forbear not to relate our intentions freely, tho we came ſhort of our *End*; yet it may ſerve for an *Advertiſement* to others, not to take a wrong Path; and perchance, excite the Ingenious to find out a means to obviate theſe *difficulties*, or a happier Journey another way.

Experiments,

Experiments,

To Meaſure the utmoſt Expanſion *of Water in* Freezing.

The Firſt Experiment.

WE made this Experiment two ways, by *Meaſure*, and by *Weight*; that by *Meaſure*, was after this manner: We procured a *glaſs Cane*, drawn as equal as poſſible; we ſealed it at one End; and filling it to a certain Mark with *Water*, we ſet it in *Ice* very well powdered, and incorporated with *Salt* to *freeze*: then comparing the height of the *Cilinder* Frozen, with that of the *Cilinder* Fluid, having the ſame *Baſes*, the *Proportion* was found to be as *Nine* to *Eight*.

The Second Experiment.

WE did not think fit to reſt ſatisfied with this one *Experiment*, judging it little leſs than impoſſible, to find a *Glaſs Cane*, (which has no other Rule to draw it by, than the equal *breath* of the *Artificer*) ſo truly *Cilindrical* as to take away all ſcruple of the *Proportion* of the *Cilinders* of Water contained therein: wherefore to have a more Regular Veſſel, we took the *Barrel* of a *Piſtol*, and turned it within to the trueſt *Cilindrical* Figure attainable by a Material Inſtrument, ſhutting the *touch-hole* with a *Steel Screw*, and covering that with a Poliſh'd *Steel Plate*, we

we poured in Six Fingers *Water*, and thruſt in a turned *Cilinder* of *Box*, of the exact Size of the remaining part of the *Tube*, well oyl'd and greaſed, that it might not imbibe any Water: when it was driven in ſo far, that the Mouth of the *Barrel* was well ſtop'd, we inverted the *Cane*, that the Water might all reſt upon the *Baſe* of the *Cilinder*, and unſcrewing the *touch-hole*, we forced the *Cilinder* of Box in further, till the Water began to run out; then ſcrewing in the *Pin* again, we ſet the Barrel upright, and marked how much of the Wood ſtood out, and covered it with the *Freezing mixture* ſprinkled with *Aqua vitæ*, which, as is well known enforces the *freezing* very much. When it had lain there about 12 Minutes, the Mark made at the *Noſe* of the *Barrel* upon the *Box*, was raiſed the thickneſs of a *Crown*, and preſently after two more, where it ſtayed, tho we reinforced the *Cold* by a great quantity of *freſh Snow* and *Salt*: after a full hour, we took the *Barrel* out, and found it ſo *cold*, that we could ſcarce endure it in our *hands*; whence we gathered, it was throughly *Frozen*: and that the rather, becauſe unſcrewing the *Touch-hole*, and ſtriking the end of the *Box Cilinder* againſt the Wall, we were not able to force it an Hairs breadth in; and except a few drops at the *Touch-hole*, we could not obſerve any Water between the *Cilinder* and *Barrel*; and by trying with a *Piercer*, we found it *Solid Ice*: for all this, we were not certain the Water was all *frozen*; nor could we be eaſily ſatisfied, becauſe of the *opacous Tube*. And 'twas poſſible ſome Water might get out at the Screw of the *Touch-hole*; and ſo part of the *Tube* between the *Cilinder* of *Ice* and *Box*, remain empty. Or in fine, the Water when at perfect *liberty*, may Rarefie in a greater *Proportion*, than it can do when under the conſtraint of a *cloſe Veſſel*, as it was here; for the *Box* was ſo fitted to the Barrel, and by imbibing the Water, notwithſtanding the Oyl ſo ſwell'd, that after the *Ice* was Thawed, and the Water poured out at the *touch-hole*, we were not able to pull it out with a pair of *Pincers*, or a *Vice*; ſo that we were forced to burn it out.

The

The Third Experiment.

BEing ſenſible of the many *Difficulties* we encountered in endeavouring to gain theſe *Proportions* by the Height of the *Cilinders* upon the ſame *Baſis*, and a *Metalline Tube*, we betook our ſelves to the other *Experiment* of *weight*: this we tryed with a Tranſparent *glaſs Cane*, and Weighed the Water put therein to *freeze*, and afterwards, as much *Ice* as filled that ſame ſpace in the *Cane*, in a pair of Scales that turned with the $\frac{1}{11}$ part of a Grane; and the *Proportion* was found to be, as 25, to 28 $\frac{1}{13}$, little leſs than that obſerved in the Firſt *Experiment* of *meaſure*, which was as 8 to 9, the ſame as 25 to 28 $\frac{1}{7}$; finding ſo great an agreement in the *proportions* not to flatter our ſelves with this *ſucceſs*, we repeated the Firſt *Experiment* with the ſame *Cane*, and found it as at firſt, as 8, to 9: and we were ſatisfied, that the *weight* was not altered for keeping the Glaſs Cane cloſe ſhut the whole time of the *freezing*, and till it Thawed again; our *Balance* ſhewed it to be of the very ſame *weight* as at firſt.

Experiments,

Touching the Procedure *of* Artificial Freezings, *with their wonderful* Accidents.

THe firſt Veſſel we made uſe of in theſe *Experiments*, was a Bolt-head of Glaſs, about 2 $\frac{1}{10}$ Inches Diameter, with a Neck about 34 Inches long, ſlender, and divi- $\frac{1}{4}$ *di Brac.* 1 *Brac.* $\frac{1}{5}$

ded into Minute Degrees; into this we poured fair Water
Tab. 41. to a Sixth Part of the Neck, then ſetting the *Bolt-head*, or
Fig. 1. Ball in the freezing Mixture, as we uſed to do to freeze Liquors; we attentively obſerved the Motion thereof, by viewing its *Superficies:* we knew before, (as indeed, few are ignorant of) That from the firſt *Application* of Cold, it contracts all Liquors, leſſening their Bulk; and this we found true, not onely in the *Aqua vitæ* of the *Thermometers*; but alſo, we had often made the *Experiment* with *fair Water*, *Oyl*, *Mercury*, and many other *Fluids*; on the other ſide we had taken notice, That the Water paſſing from a Simple Coldneſs, to loſe its *Fluidity*, and receive *conſiſtency*, and *firmneſs* by *Glaciation*, does not onely return to its firſt *Bulk*, but ſo far Exceed it, as to burſt Veſſels of *Glaſs*, and *Metal* with great *violence*. But we were yet ignorant, what *Period* theſe ſeveral *alterations* (produced by *cold*) obſerved; neither was it poſſible for us to attain it in Opake Veſſels, as thoſe of *Silver*, *Braſs*, and *Gold* were, hitherto made uſe of in the Freezings: wherefore not to fail in this, which ſeemed to be the very *Life* of all theſe *Experiments*; we had recourſe to Veſſels of *Criſtal*, and *Glaſs*, hoping by the *Tranſparency* of the *materials*, to be ſatisfied in the proceedure of the *Experiment*; ſince upon every Motion of the Level in the Neck, we might take the Veſſel out of the mixture, and mark the correſpondent *alteration* therein. But the truth is, we found greater trouble than at firſt we imagined; to gain any certainty as to the *Periods* of theſe *Accidents*.

But to relate the *ſucceſs* more *diſtinctly*, you muſt know, That upon the firſt *immerſion* of the Ball, as ſoon as ever it touch'd the *freezing Mixture*, we obſerved in the Water in the Neck a little riſing, but very quick, which ſoon ſubſiding, it fell in the *Neck*, with a Motion regular enough and a moderate *Velocity* retiring to the Ball, till arriving at a certain degree, it ſtop'd for ſome time, as far as our Eyes could judge, *immovable*. Then by little and little it *remounted*, but with a very ſlow Motion, and apparently

equal,

equal, and then of a ſudden without any proportionate *acceleration* it flew up with a *furious Spring:* at which time it was impoſſible to follow it any longer with the Eye, inſtantaneouſly running through the *Decades* of Degrees. And as this *fury* began of a ſudden, ſo of a ſudden it ceaſed, changing from that great ſwiftneſs to a *movement*, though very faſt, yet incomparably leſs ſwift than the *precedent:* and with this it continued to riſe moſt commonly, till it ran over the Top of the Neck; and all the while theſe things happened, were obſerved ſeveral little *corpuſcles* of *air*, or ſome other more ſubtil Body to ariſe, and paſs through the Water, ſometimes in a greater, ſometimes in a leſs *Proportion:* this ſeparation was not viſible, till the Water began to receive an *intenſe* Degree of *cold*, as if the force of the *Cold* had the faculty of *ſecreting* ſuch a matter from the Water. After this, we were willing to ſee, if theſe *Alterations* kept any kind of *equality* or *proportion* with each other; wherefore we repeated the *freezings*, ſcarce one *Ice* being diſſolved, but we ſet it again to *freeze:* but the Water always *froze* with the ſame *Series* of *Changes:* yet becauſe they did not ſtill every time riſe to the ſame Marks or Degrees in the Neck, we began to imagine, there was no fixt *Period*; for which, it ſeemed we had ſome reaſon. At laſt it happened, that in often repeating theſe *Experiments*, we by chance let the Water in the *Bolt-head* freeze in the Neck firſt: (of which we ſpake in the Fourth *Experiment* of *freezing*,) and ſo brake our Veſſel. Whereupon, we were forced to make another; this we blew leſs than the former, that the *cold* might ſoon Inſinuate it ſelf through all the Water; we alſo made the Neck longer, to the height of 45 $\frac{1}{10}$ Inches, that it ſhould not run over. This we filled to 160 *deg.* and ſet it to freeze in *Ice* very diligently; heeding it we found at firſt, that all the *accidents* of *ſubſiding*, *riſing*, *reſting*, *remounting*, *ſwiftly running up*, and *ſtopping* again, were the very ſame; (*i. e.*) happened always when the *Level* of the Water was at the ſame Mark or Degree in the *Neck*; for upon putting it in the *Ice*, we obſerved, it was reduced to the ſame Degree, as in

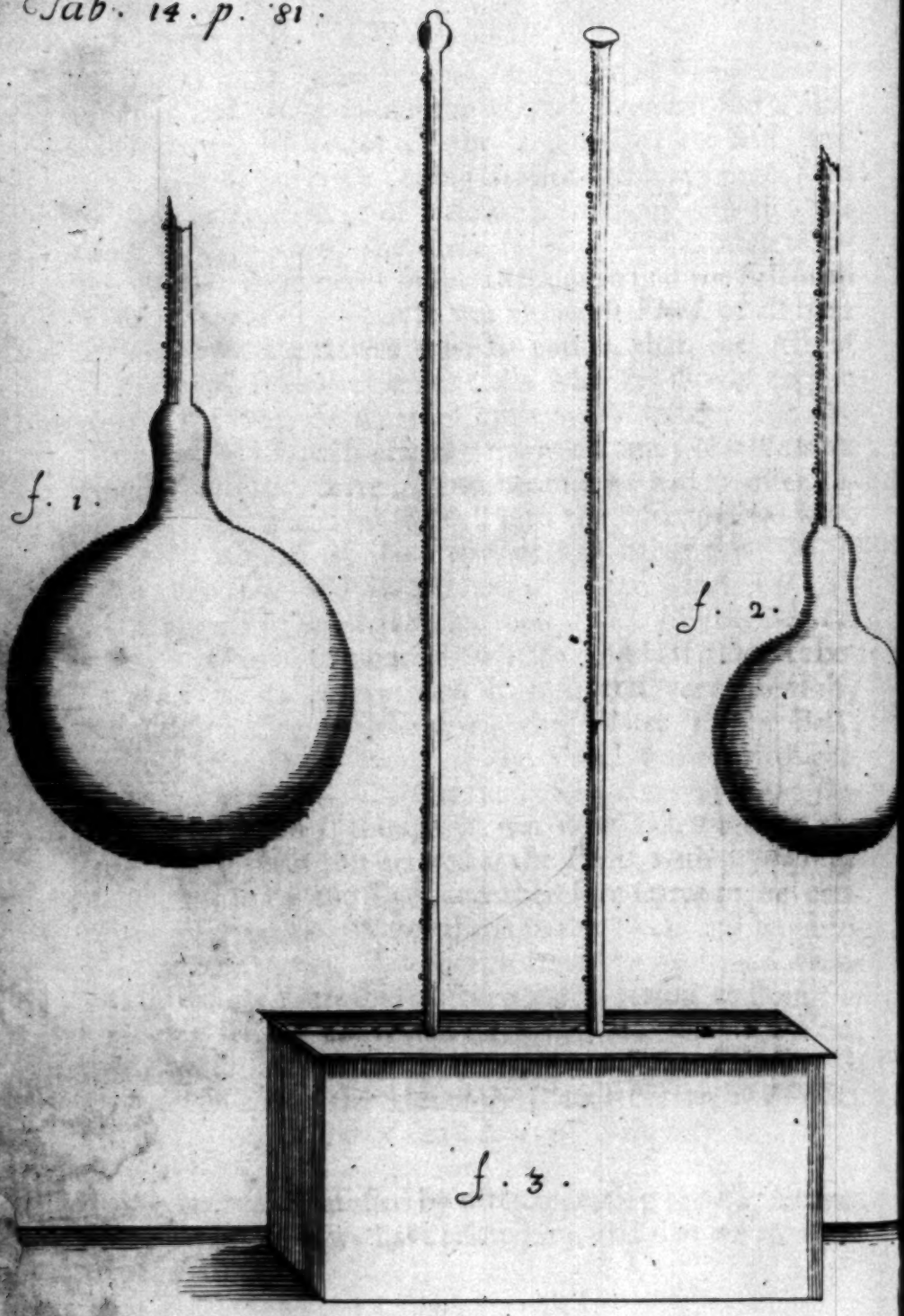
Tab. 14. *Fig.* 2. 2 *Brac.*

the former *Tryal*: that is to ſay, at the ſame Temperament of *Heat* and *Cold*; taking the whole Inſtrument for a nice *Thermometer*, by reaſon of the largeneſs of the Ball, and proportion of the Neck; being ſatisfied ſo far, we proceeded to find the *exact* time of *freezing*; and to obtain this, we took the Ball out of the Mixture often, yet as often as we tryed it, we were never ſo ſucceſsful as to find the firſt ſmall Veins, or *ſtiriæ* of *Ice*, but it was either all *Fluid*, or all over *Frozen*; whence it was eaſie to gather, that the Act of *Glaciation* muſt be very quick: and whoever ſhould happen to take it out of the Mixture in the very inſtant that the Water begins its ſwift *careere*; might certainly obſerve ſome Notable *alteration* therein: and becauſe we had ſo often taken out, and immerſed the Ball into the Mixture, we were not well aſſured of the *Point* of its Change; we let it ſtand therefore, and be reduced to its firſt Mark, and placed it again in the *mixture*, and took notice of the Degrees whereat it began to mount ſo ſwiftly; and half a Degree before it came to it, we took it out, and very heedfully regarding it with the *Eye*, the Water in the Ball, through the *Tranſparency* of the Veſſel was eaſily diſcerned to be yet all Fluid; but the before received *Impreſſion* of *cold* ſtill acting (though it was now taken out of the *Ice*) when it was juſt arrived at the *Point*, with a *ſwiftneſs* indiſcernable by the Eye, and therefore ſcarce to be conceived, forced the Water through the Neck, and in an inſtant took away all *Tranſparency* from the Ball, and changed its Fluidity into *Ice*. There was no reaſon to doubt of its being wholly converted into *Ice*; and that it was not onely outwardly cruſted over, becauſe in Thawing it looſened firſt from the ſides of the Glaſs, leſſening by degrees, till at laſt it was like a ſmall *Lens* of *Ice* which was in the End Diſſolved.

We were well ſatisfied by often repeating the *Experiment*, that it was juſt as we have related it; and that we were not impoſed upon.

We

Tab. 14. p. 81.



We were after this, very desirous to see the *Order* and *Method* observed by divers *Liquors* in *freezings* which for brevity are set down in the following Tables; wherein

STATE NATURAL, signifies, the Degree whereat the Water, or other Fluid stood (before *Glaciation*) in the Neck of the Vessel. *Stato Naturale.*

RISE UPON IMMERSION, is the first Leap made by the Water upon the Balls first touching the *freezing* Mixture. *Salto dell Immersione.*

This, (as the following *Experiments* will more clearly shew) proceeded not from any *Intrinsic Alteration* of the *Fluid*; but from the *Extrinsic* cause of the Vessel: whence it is, that varying sometimes a little, it Communicated some variety to the other Changes through which the *Liquor* passed in *freezing*; but whereas this is it self but small, its *variety* is also but little, and what it communicates to the subsequent Changes very inconsiderable.

ABATEMENT, or Fall, denotes the Degree to which the Water is reduced (after the *Rice upon Immersion*) when it just begins to receive the *Impression* of *Cold*. *Abbassamento. Quiete.*

REST. Is the Degree whereat the Water stands for some time after its *fall*, without any apparent Motion.

REMOUNTING, shews likewise the Degree to which the Water is raised from its lowest fall, by means of *Rarifaction*, with a very slow, and seemingly equal Motion, altogether like the first, wherewith it subsided. *Sollevamento.*

SPRING UPON GLACIATION, signifies the Degree to which the Water rises with that extream Velocity *Salto dell' Aggbiacciamento.*

Velocity upon the very point of *Glaciation.*

We ſaid before, that after this *Spring* or *Start*, the Water does not ſtop upon a ſudden, but continues to riſe with a Motion ſwift enough, though incomparably leſs than the *preceding*: but of this *Subſequent Motion*, we have taken no account, it proceeding onely from the *Proſecution* of *Rariſaction* in the *Ice* already made, or to ſay better, from the *Ice* ſhooting in the Ball by little and little, as it hardens after the *fury* of the firſt *Impetus*. This we call the firſt ſhooting of *Ice*, which is (as we have found upon breaking the Balls) from a very *tender* and weak *beginning*; and like *Sherbet*, when it is a little too hard, being of no cloſer a Conſiſtence than the firſt *coagulations* of *Liquors*. Moreover, it happens that this way of *Freezing*, ſhews not the utmoſt *Rarefaction* of *Fluids* violently *frozen*, it being impoſſible without burſting our Inſtrument to reduce the *Ice* to a perfect *Solidity*.

We have likewiſe, to ſhew our utmoſt *diligence*, and *exactneſs*, made uſe of a *Thermometer* and *Pendulum* in each Experiment of *freezing*: that with the *Thermometer* we might ſee at what Degree of *cold*, and with the *Pendulum* at what time every change happened to the *Liquors*: where-
Tab. 14 *Fig.* 3. fore in the ſame *Box* with the Ball, or *Bolt-head*, we put a *Thermometer* of 400 *deg.* but indeed, we found great inconveniencies, both in Noting the Degrees of *cold* ſhewn by the *Thermometer*, and the ſpaces of Time given by the Vibrations of the *Pendulum*; ſo that we muſt confeſs, all our diligence was fruitleſs through the difficulty and impracticableneſs of applying an equal *Proportion* of *cold* to the *Ball*, and to the *Thermometer*; by reaſon of the *inequality* of the Pieces of *Ice*, and *quantity* of *Salt* ſprinkled. And the cauſe is, That in *Artificial Freezing* we make uſe of *Snow* or *Ice*, which though ever ſo well bruiſed, and as it were ground to *powder*; yet upon mixing it with the *Salt*, they become one *Solid Maſs*, and as hard as *Stone*; ſo that it is impoſſible to cloſe it round about the Veſſel,

or

or be assured, that it touches every where alike: yet rather than be *deficient*, we have set both down in our *Tables*, that is, the Degrees of the *Thermometer*, and the *Vibrations* of the *Pendulum*; leaving it to the *discretion* of the *Reader*, to make a due Estimation of such *Remarques*.

The First Freezing

Of Spring Water.

	The Deg. of the Vessel.	*Differ.*	*Deg. of* Therm.	*Differ.*	*Vibrat.*	*Diff.*
State Natural	142		139			
Rice upon Immer.	143 ½	1 ½	133	6	23	23
Abatement.	120	23 ½	69	64	255	232
Rest.	120		49	20	330	75
Remounting.	130	10	33	16	462	132
Spring upon Glaciat.	166	36	33			

Note, That 65 of the *Vibrations* of the *Pendulum* set down in this, and the Four following Tables made one Minute.

The Second Freezing

Of the same Spring Water.

	Deg. of Vessel.	*Diff.*	*Deg. of Therm.*	*Diff.*	*Vibrat.*	*Diff.*
State Natural.	144		141 ½			
Rice upon Immers.	146 ½	2 ½	118	23 ½	25	25
Abatement.	119 ½	27	38	80	280	255
Rest	119 ½		28	10	415	135
Remounting.	131	11 ½	17	11	882	467
Spring upon Glaciat.	170	39	17			

The

The Third Freezing.

Of the ſame.

	Deg. of Veſſel.	Diff.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	143		141½			
Rice upon Immerſion	145	2	125	16½	23	23
Abatement	119½	25 ½	51	74	369	346
Reſt	119½		44	7	565	196
Remounting	129½	10	38	6	933	368
Spring upon Glaciat.	169	39½	38			

From theſe Three *Examples* of *Freezing*, the ſame Water may be obſerved, That the *ſtate Natural* of the Water was not all three times exactly at the ſame Degree cauſed by the *different temperament* it had at one time, from what it had at another, from the *External* Accidents of *Heat* and *Cold*; whence likewiſe all the other *alterations* happening to the Water, did not preciſely keep their *Degrees*; nevertheleſs by reducing in the *ſecond* and *third Experiments* the *ſtate Natural* to 142 *deg.* and alſo ſubſtracting in the like Proportion from all the other heights, you will find that they differ from the *Degrees* noted in the *firſt Table* very inconſiderably.

The First Freezing

Of Mirtle Flower *water drawn off in a cold Still.*

Acqua di fiori di Mortella

	Deg. of Vessel.	Diff.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	145 1/2		141 1/2			
Rise upon Immers.	147	1 1/2	133	8 1/2	31	31
Abatement	109	38	49 1/2	83 1/2	347	316
Rest	109		45	4 1/2	387	40
Remounting	125	16	25 1/2	19 1/2	925	538
Spring upon Glaciat.	230	105	25 1/2			

The Second Freezing

Of the same Water.

	Deg. of Vessel.	Diff.	Deg. of Therm.	Diff.	Vibrat	Diff.
State Natural	146		142			
Rise upon Immers.	149 1/2	3 1/2	131	11	18	18
Abatement	108	41 1/2	35	96	460	442
Rest	108		32 1/2	2 1/2	518	58
Remounting	126 1/2	18 1/2	19 1/2	13 1/2	1327	809
Spring upon Glaciat.	232	106	19 1/2			

In the following *Experiments* of *Freezing*, we changed our *Pendulum* taking one 60, of whose *Vibrations* made an Exact *Minute*.

The First Freezing

Acqua Rosa.

Of simple Rose-Water *still'd in a Cold Still.*

	Deg. of Vessel.	Diff.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	140½		142			
Rise upon Immers.	143	2½	138	4	20	20
Abatement	116	27	50	88	351	331
Rest	116		46	4	389	38
Remounting	127	11½	26	20	745	356
Spring upon Glaciat.	194	67	26			

The Second Freezing

Of the same Water.

	Deg. of Vessel.	Diff.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	140½		141			
Rise upon Immers.	142½	1	125	16	21	21
Abatement	115½	27	39	86	354	333
Rest	115½		29½	9½	522	168
Remounting	127	11½	18½	11	1257	735
Spring upon Glaciat.	194	67	18½			

The

The First Freezing

Of Orange-flower *Water drawn off in a* cold Still.

Acqua di fiori di Aranci.

	Deg. of Vessel.	*Diff.*	*Deg. of Therm.*	*Diff.*	*Vibrat.*	*Diff.*
State Natural	137		142			
Rise upon Immers.	139	2	130	12	29	14
Abatement	111	28	46 1/2	83 1/2	311	297
Rest	111		44 1/2	2	375	64
Remounting	127	16	20 1/2	24	880	505
Spring upon Glaciat.	250	123	20 1/2			

In all the *Tables* of the *Second Freezings* of the above-named *Liquors* many be observed how much longer time was requisite to Freeze it the *second* time, than the *first*; which we taking notice of, were willing to discover, whether it arose from any *intrinsick* cause in the Liquors after their suffering the *first Freezing*; or from an *External* cause in the *Ice's* being less *cold* after it had suffered the first incorporating with the *Salt*: and for this intent, we emptied the Case, and putting in fresh *Ice* and *Salt*, we made Trial of

The Second Freezing

Of the same Water.

	Deg. of Vessel.	*Diff.*	*Deg. of Therm.*	*Diff.*	*Vibrat*	*Diff.*
State Natural	137 1/2		142			
Rise upon Immers.	140	2 1/2	120	22	29	29
Abatement	111 1/2	28 1/2	46	74	366	337
Rest	111 1/2		44	2	384	18
Remounting	127	15 1/2	31 1/2	12 1/2	907	523
Spring upon Glaciat.	248	121	31 1/2			

So that the *Difference* in time between the *First* and *Second Freezings* must not be attributed to the *Liquors*, but to the *Ice*, which being much *dissolved*, and *weakned*, its Freezing Power arising from the *salt* requires a longer time to perform its *Operation*; and indeed, the whole *difference* between the *two Freezings* of the *Orange Flower* Water amounted but to a *Minute* and 46 *Seconds*; whereas, when the mixture was not changed, it arose to 7 *minutes* 29 *seconds*; nay, to 13 *Minutes* 20 *Seconds*; as appears by the comparing of the *First* and *Second* Freezings of the *Rose-water*, and the *First* and *Third* Freezings of the *Spring water*; and that the small difference of 1 *Minute* 46 *Seconds* observed in the *Second* Freezing of *Orange-flower* Water, was meerly *accidental*, and not from any *resistance* acquired by the *Water* in being once before Frozen; is Evident from the *Second* Table of the Freezing of *Strawberry*-Water, following, where the *Ice* being changed, the *Second* Freezing happened in 3 *Minutes* 15 *Seconds* less time than the *First*.

The First Freezing

Aqua di Fraole Straw-berry Water *still'd in* Balneo.

	Deg of Vessel.	*Diff.*	*Deg. of Therm.*	*Diff.*	*Vibrat.*	*Diff.*
State Natural	137		143			
Rise upon Immers.	139	2	120	23	30	30
Abatement	111	28	37	83	437	450
Rest	111		36	1	450	15
Remounting	126	15	18 1/4	17 1/4	988	538
Spring upon Glaciat.	215	89	18 1/4			

The

The Second Freezing

Of the ſame Water.

	Deg. of Veſſel.	Diff.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	139		143 ½			
Riſe upon Immerſ.	141	2	134 ½	9	18	18
Abatement	114	27	42	92 ½	420	402
Reſt	114		41	1	427	7
Remounting	129	15	21	20	873	446
Spring upon Glaciat.	215	86	21			

Note, That the *Spring upon Glaciation* is more or leſs high, as likewiſe more or leſs ſwift in Different *Fluids*: and it ſeems to be higher and ſwifter in thoſe that Freeze ſtronger.

The Freezing

Of Still'd Cinamon Water.

Acqua di Cannella.

	Deg. of Veſſel.	Diff.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	139 ½		141			
Riſe upon Immerſ.	141	1 ½	133 ½	7 ½	13	13
Abatement	111 ½	29 ½	45	88 ½	360	347
Reſt	111 ½		39	6	420	60
Remounting	120 ½	9	27	12	720	300

The Water riſing with a very *ſlow* Motion from the *State of Reſt* to 120 *deg.* ½ inſtead of *ſpringing* up as it then uſes to do, it onely mounted with a quicker pace; which perceiving, we immediatly took the Veſſel out of the *mix-*

ture, and found the Water ſhot into a very tender *Ice*, which melted as ſoon as ever it was ſenſible of the *Air*. And *Note*, That of theſe *Artificial Freezings*, ſome were more weak and tender, as the *Ice* of *Cinnamon Water*, and that of *Roſe-water*; others more firm and hard, as that of *Orange*, and *Mirtle-Flower-waters*; than which we found no Liquors ſo hardned at the firſt inſtantaneous *Freezing*.

We have omitted the repetition of this, and the following *freezings*, ſince their agreement may be ſufficiently ſeen in the Examples given of each *Liquor*.

The Freezing

Of Snow Water.

Acqua di Neve Strutta.

	Deg. of Veſſel.	*Diff.*	*Deg. of Therm.*	*Diff.*	*Vibrat.*	*Diff.*
State Natural.	136½		141			
Riſe upon Immerſ.	139	2½	132	9	27	27
Abatement.	111	28	52	80	345	318
Reſt.	111		48	4	377	32
Remounting.	116½	5½	40	8		

And then with a ſomewhat quicker *motion* (tho very ſlow in compariſon of that which the other *Liquors* ſprung up with upon the point of *Glaciation*) it began to congeal at the ſides of the *Glaſs*, and ſucceſſively from the more outward parts approach'd the *Center* of the Veſſel with the ſame equal ſlowneſs of *Rarefaction*, and raiſing of the *Level* in the *Neck*. The *Ice* was not throughout equal as the other, but broken, and ſhot into irregular *Veins* and *Rays*, and every where interwoven: being repeated, the *ſecond Freezing* was in all reſpects the ſame as the *firſt*; And making it with the ſame Water boil'd, we found no great *difference*.

The

The Freezing
Of Fig-Water.

Acqua della Ficoncella.

	Deg. of Vessel.	Diff.	Vibrat.	Diff.
State Natural	98			
Rise upon Immers.	100	2	19	19
Abatement	71	29	288	269
Rest	71		363	75
Remounting	83	12	816	453
Spring upon Glaciat.	200	117		

The Freezing
Of the best red Florence *Wine.*

Vini Rosso di Chianti.

	Deg. of Vessel.	Differ.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	141		141			
Rise upon Immer.	143	2	13 7	4	15	15
Abatement.	77 ½	65 ½	27 ½	109 ½	600	585
Rest	77 ½		23 ½	4	695	95
Remounting.	81	4	15	7 ½	1035	340

From the 81 ½ *Deg.* it visibly accelerated the *Motion* of the *Level*, and by little and little *froze* without any other *motion* in the *Vessel*,

The

The Freezing

Of white Muſcadine.

Muſcadello Bianco.

The Deg. of the Veſſel.		*Differ.*	*Deg. of* Therm.	*Differ.*	*Vibrat.*	*Diff.*
State Natural	140		139			
Riſe upon Immer.	142 $\frac{1}{2}$	2 $\frac{1}{2}$	132	7	16	16
Abatement.	77	65 $\frac{1}{2}$	24	108	660	644

Being come to that *Degree* of 77 without any *reſt* or *ſtop*, it began to riſe with a little ſwifter Motion than we obſerved the *Liquors* uſed to remount with, which Freeze in the inſtant of that they exert their *violent ſpring*. When we took it out, we found the Liquor began to have ſome *Ice* next the ſides of the Glaſs.

The Freezing

Of Diſtill'd Vinegar.

Aceto Bianco.

	Deg. of Veſſel.	*Diff.*	*Deg. of Therm.*	*Diff.*	*Vibrat.*	*Diff.*
State Natural.	141		140			
Riſe upon Immerſ.	143	2	134	14	11	11
Abatement.	75	68	24	110	735	724
Remounting.	79	4	19	5	1175	440
Spring upon Glaciat.	273	194	19			

Which Velocity was leſs than that of the Freezing Water, but conſiderably greater than that of *Muſcadine*, *Cinamon Water*, and *Simple Vinegar*.

The

The Freezing

Of the Juice *of* Limons

Agro di Limoni.

	Deg. of Veſſel.	Diff.	Deg. of Therm.	Diff.
State Natural	142		143	
Riſe upon Immerſion	144	2	134	9
Abatement	84	160	32	102

When it was fallen to the 84*th degree* of the Veſſel, it began to riſe again with a very ſlow *motion*, gently *freezing*.

The Freezing.

Of Spirit *of* Vitriol.

Spirito di Vitriolo.

	Deg. of Veſſel.	Diff.	Deg. of Therm.	Diff.	Vibrat.	Diff.
State Natural	140 $\frac{1}{2}$		140 $\frac{1}{2}$			
Riſe upon Immerſ.	142	1 $\frac{1}{2}$	133	7 $\frac{1}{2}$	15	15
Abatement	90	52	37 $\frac{1}{2}$	95 $\frac{1}{2}$	420	405

This *Liquor* did likewiſe not reſt at all, but being reduced to 90 *deg.* began to remount in the *Neck* of the Veſſel with a ſlow uniform *motion*, and at the ſame time ſhot it ſelf in ſeveral *planes* of *ice* from place to place in the Liquor, as is the manner of *fair water* ſet to *freeze* by it ſelf in the open *air*.

The Freezing

Of Oyl.

Olio.

	Deg. of Veſſel.	*Diff.*
State Natural	140	18
Fall upon Immerſ.	122	
Abatement		

When it had contracted it ſelf all within the *Body* of the Veſſel it there *congealed* without the leaſt *Rarefaction*: for it may be the Frozen *Oyl* ſinks to the bottom of the *Fluid*, whereas all other *Ice* ſwims upon their *Fluids*.

Spirit of Wine condenſes extreamly, but never *Rarifies* afterwards, nor affords any *ice*.

EXPERIMENTS
OF
Natural Freezing.

ALthough the *Freezings* we have hitherto Treated of, have been called by us *Artificial*; yet that takes not from their being the true Works of *Natures* own hand. Now the ſame *Nature* Acting by other *Methods*, and it may be with the onely *ingredient* of the *Air*, we were curious to know, if any *variety* in the *Procedure* of the *Operations*, might be diſcovered in producing the ſame *Effects* by other means. And when we already had this before us, we attempted to draw thence ſome other Concluſions; as will appear in the following *Diſcourſe*.

The Firſt Experiment.

Of the Freezing of common Water *in the* Air.

IT is already declared, in the foregoing *Experiments*, that the *Artificial Ice* (in the then deſcribed Veſſels) proceeded from a *beginning* very *ſoft*, and *incompact*; eſpecially, in regard of thoſe made in the *Winter air*; which, tho they are not ſo ſuddenly made, but begin from a thin *coat*, or hair-like *Vein*, ſcarce diſcernable; yet thoſe *Veins*, or *Coats* (excepting their *brittleneſs*, which comes from their being

ſo very ſmall) are more firm, and hard Bodies, and as it were more *Criſtaline*, and Solid *Ice*. And very admirable is that *Luſus Naturæ* which for many years we have obſerv'd in *Natural Freezings*, viz. Setting Water taken out of the ſame *Spring* in ſeveral Veſſels, as of *Earth*, of *Metal*, and of *Glaſs*; in the ſhape of tall *Glaſſes*, or broad *Bowles*, ſome part-filled, ſome quite-fill'd; ſome open, others covered, and in ſeveral ſorts of *bottles*, with different Mouths; ſome onely ſtop'd with *Cotton*, others ſealed at a *Flame*, being all ſet in the ſame place undiſturbed, or beſide one another upon a Table: ſometimes that Veſſel which had leaſt, was firſt *Frozen*; ſometimes that which had moſt, and ſo in all the Veſſels, without any regard had of the *form*, or *fullneſs* thereof.

As to the *Materials*, we may poſitively aver, That *Earthen Veſſels* freeze the contained *Fluid* ſooner than either *Metal*, or *Glaſs*. But as to the reſt, we have found nothing ſo conſtant, as the *perpetual irregularity* of the *Accidents*; and among others, there have ſome Veſſels ſtood all *Night* without the leaſt Coat of *Ice*, when ſome next to them have been *frozen* in an *hour*. Moreover, in the ſame ſort of Veſſels ſet to *freeze*, in the ſame *Night*, we have obſerved the like *varieties*, whether placed *North*, *South*, *Eaſt* or *Weſt*; and as well thoſe Veſſels which have ſtood more *Southwardly* have been *frozen* firſt, as at other times, thoſe that ſtood more *Northwardly*, tho the *Cold* generally comes from that Tract with us: and ſometimes thoſe *Eaſtward*, ſometimes thoſe *Weſtward* have got the better; nay ſometimes both have ſurpaſſed the *North*, and *South*, and at other times been vanquiſh'd by them.

The *Method* alſo obſerved in *Freezing*, is very curious: The *water* begins firſt to congeal at the *top* round the *edges*, and from that Liſt of *Ice* ſhoots ſeveral ſmall *Threads* to the *middle*, after which it ſends others downwards, and that indifferently from all parts; by degrees theſe *Threads* became ragged, yet *thicker*, and *broader* at one end, and more *acute* at the other, like little *Daggers*; from the ſides of theſe

theſe ſhoot out other ſmall *Threads* cloſe together like *feathers*, or *Palm branches*; theſe are as it were the firſt *warping*, and with a confuſed, and diſorderly filling up, they proceed ſhooting and increaſing till the *Wooſe* cloſes all with a total *freezing* of the Water; the *Superficies* whereof may be perceived to be all raz'd, and full of ſtrait Lines, like *Criſtal* ſcratcht with a fine *Graver*. At firſt the *Superficies* of all theſe *Ices* appears plain; but when the *freezing* is throughly finiſh'd, and all the *Water* Congealed, it at laſt becomes raiſed in *hillocks*, but without any *regular* Figure. This *Effect* made ſome call to mind what was Regiſtred in our firſt *Experiment* of *Artificial Freezing*, where the innermoſt *Cover* of the *Silver Veſſel* was found crack'd, and all Coated over with a thin *Ice* made of the *water* that got out of the *Veſſel* at the *crack* in the inſtant of *freezing*; thereupon they ſaid, that the firſt *Cruſt* of *Ice* which ſpreads it ſelf over the *Superficies* of the *Water*, and ſhuts it cloſer than any Cover can, by ſticking faſt to the ſides of the Veſſel; does not leave *ſpace* enough for the *Water* under it to *rarifie* in, as it *freezes*, but it is forced to ſeek *room* where it can; and finding the *Cake* of *Ice* weaker than the *ſides* of the *Veſſel*, it makes its way there, and heaps it ſelf up more in one place than another, according to the inclination of the plains in which it breaks, when the firſt Cake ſplits, which afterwards likewiſe *freezing*, forms that little ſwelling mentioned: this happens ſometimes to break the *Veſſels*, which (as they think) is moſt probably cauſed, by the *ſlowneſs* of the *Waters freezing* at the *bottom*; whereby the *Cake* of *Ice* at the *top* becomes ſo hard, that it is eaſier to break the ſides of the Veſſels than the *Icey Cover*: but no certain *Rule* can be given concerning theſe *matters*, ſince there may be many *caſes* wherein either the *Veſſel* is onely *burſt*, or the *Cover* onely: or firſt one, then the other; or both at the ſame time, according as the *External* accidents of the *Air* vary; as to *cold*, *calmneſs*, or *winds*; and from the *inequality* of the *Veſſels* Reſiſtance, or from the Nature of the *Liquors* themſelves.

Before we put an End to this *Diſcourſe*; it will not be amiſs

amiss to Relate a trifling *Accident* observed this year, which though of small *Moment*, may nevertheless be some help to the former *Opinion*. A *cup* of *Water* being exposed to the *Air* in the *Evening*, we found in the *Morning* all the Water *frozen*; and in the highest part of its *Superficies* it had a *Point* of *Ice* a *Finger* high, like a small sharp *splinter* of *Rock Cristal*: This in all likelihood was no other than the Water issuing out at a *crack* in the first *incrustation*, being forced by the *freezing*, underneath, which violently rising in a small stream, (and predispos'd to *Freeze*,) by the *Cold* of the *external Air*, was congealed to an hard *Ice*, in that very instant, not having time to fall.

The Second Experiment

Of the Freezing *of* Water *in* Vacuo.

WE have likewise tryed to *Freeze* Water in a *Vacuum* made with *Mercury*: and that we might compare it with that made in the *Air*, we put *Water* in a Vessel like that included in the *Vacuum*. Therefore exposing them all *Night*, we found in the *Morning* both *frozen*: yet with this *Difference*; that the *Ice* made in *Vacuo* seemed more *equal* and *hard*, and less *transparent* and *porous* than the other; and upon Examination, was heavier in *specie*. The way we took to discover this, was by turning a piece of each *Ice* like a *Cilinder*, and of the same *bulk*, as near as we could, and putting them in *Spirit* of *Wine*, upon which gently pouring some *Red Wine*, we saw the *Ice* made in the *Air* rise up before that made in *Vacuo*; and when upon the *top* of the Water, it swam about lighter, and quicker because the *Fluid* covered less of it, than of the other.

The

The Third Experiment

Of the Freezing *of* Still'd Water.

HAving ſet common *Still'd Water* in ſeveral Vials to *freeze*, we found the *Ice* more *limpid* and *tranſparent* than uſually the *water* is: onely in the *midſt* there was as much as a *ſmall Nut* of a more *opaque Ice*, and whiter than the *reſt*, and round about it divers *ſpiculæ* of the ſame kind of *Ice*: in fine, to give a true *Picture* of it, in each *Vial* 'twas like the *Burre* or *Huſk* of a *Cheſtnut*, frozen in a piece of *Rock-Criſtal*, as we ſee *Flys*, *Worms*, or *Butter-flys* entombed in *Amber*; or like little bits of *Straw*, *Herbs*, &c. in *Criſtal* it ſelf.

The Fourth Experiment,

Of the Freezing of Sea Water.

TO ſee the *Freezing* of *Sea water*, we expoſed one *Evening* to the *Air* (when a *Thermometer* of 50 *deg.* ſtood at 9°, two Glaſſes full of it, to *freeze*: in an hour we found the *ſhalloweſt* began to *freeze*; but in a manner ſomewhat different from *common* Water; for it ſhewed like a great many ſmall ſcales of *Talke* broken to pieces, and put in Water. Theſe took away the *Traſparency* of the *Water*, and gave it the conſiſtence of *Sherbet*, which is drank *frozen* in the *Summer*, when the *Externally* applyed *Snow* growing more Languid, it begins to diſſolve. In a while looking upon it again, we obſerved it a little firmer, as the Multiplying of the Scales leſſened the *Fluidity* of the *water*; in the *morning*

morning it was yet harder, tho it came nothing near the hardneſs of *common Ice*; for upon any little *agitation*, it turned to *water*: the Figure of the *Scales* was narrow, and longiſh, and between them it was for the moſt part *Fluid*: moreover, the *Maſs* ſtuck no where to the *ſides* of the *Veſſel*; but turned freely about in it. The *Superficies* was altogether plain, without any *prominences*, or *Riſings*: And the *Difference* conſiſted wholly in a more looſe and thin *Order* and *Texture* then that of *ordinary Ice*.

The Fifth Experiment,

Of the Efficacy *of* Sal-Armoniac, Nitre, *&c. in* Freezing.

IT is well known, that *Ice* is moſt *efficaciouſly* cold when ſprinkled over with *Salt*. As to this we have obſerved, That *Sal-Armoniac* invigorates it more than any other; for we have *experimented* it upon the ſame *water*, of the ſame *Temperament*, and in like *Veſſels* of the ſame *figure*, *capacity*, and *thinneſs*, equally encompaſſed with the like quantity of beaten *ice*, and the one being ſprinkled with *Sal-Armoniac*, the other with the ſame *proportion* of *Nitre*, they were not *frozen* in the ſame *ſpace* of time: for a *Thermometer* of 100 *deg.* being (when it ſtood at 20 *deg.*) Immerſed in Water ſet to *freeze* with *Nitre*, ſubſided but to $7\frac{1}{2}$ *deg.* when at the ſame time a like *Thermometer* put in Water, encompaſſed with the mixture of *Sal-Armoniac*, fell down to 5 *deg.* and the Water began to be skinned over.

We have already ſaid, upon another accompt, That not onely *Salt*, but *ſtrong-Waters* wonderfully intend the *freezing*; and if beſides the *ſtrong-Water*, you add *ſalt*, it will prove moſt powerful: nay, *ſugar* produces ſuch an Effect, but

but not much in compariſon of common *Salt*, *Nitre*, and *Sal-armoniac*, which we found much more ſucceſsful in the *operation* of *freezing*, than all the Reſt.

The Sixth Experiment.

Touching what Metal *preſerves* Ice *beſt.*

PUtting *Ice* in Veſſels of ſeveral different *Metals* to obſerve which kept it the longeſt *unthaw'd*; yet, of this we could obtain nothing certain, tho we may ſay at large from a very great number of *Experiments* which we made, that it was preſerved beſt of all in *Lead*, very well in *Tin*, but a ſhort time in *Copper*, and *Iron*, leſs in *Gold*, and yet a leſſer time in *Silver*; nevertheleſs, at ſometimes this order was changed, it *melting* ſooner in *Tin* and *Lead*, than in *Silver* and *Gold*: wherefore (as we hinted) this *Experiment* is not to be much confided in, but propoſed here rather to excite others to attempt it by ſome more ſecure way, than to ſhew any certainty we obtained in our Obſervations.

Piombo
Stagno
Rame
Ferro
oro
Argento.

The Seventh Experiment

Of Freezing *a Piece of* Ice *to a* Table.

G*Aſſendus* Writes, and it is very true, That if a *Plate* of *Ice* be laid upon a flat *Table*, and well ſprinkled above with *Salt*, it will *freeze* faſt down to the *Table*: we were deſirous to make the ſame *Experiment* with *Nitre*, but it ſucceeded not, ſo as to ſhew us the leaſt *beginning* of *Adhæſion*: we have often obſerved in thoſe ſtuck down with *common Salt*, that we much more eaſily ſeparated them from the Ta-

ble, by lifting them up *Perpendicularly* (or at one end first, as a Board nailed down is raised up with a *Lever*) than they could be forced along *parallel* to the Plain; moreover, the Water on the *under-side* of the *Ice* was *Salt*, and that *side* also thereof was *Opake*, and covered with a white *hoariness* made of innumerable small *particles* of *Salt*: and brought to the Light, it appeared rough, as if it had been prettily razed with the point of a *Diamond*; like the Glass of those Vessels, which from the *Artificial* similitude they have to *Ice*, we call *Ice-glasses*.

The Eighth Experiment.

Of freezing *the* Dew *upon the* outsides *of* Vessels.

THat *Dew* which covers the *outsides* of Glasses, containing any *cold* Liquor, or *Ice*, is sometimes observed to congeal there: and the same happens, when the *Ice* or *Snow* in the Vessel begins to alter with the *strong Water* or *Salt*: there is also an *Exhalation*, or cloudy moist Vapour rises up as it seems from the bottom of the Vessels, whence proceeds a very cold *air*, which besides that it sensibly affects the *hand*, is likewise more discernable, by the *agitation* which it causes in the *flame* of a Candle brought near it.

This *Experiment* we repeated, by putting *Ice* sprinkled with *strong water* and *Salt* in several Vessels of different *Figures* and *Metals*; to observe if either the one, or the other afford any *variety* in the *smoaking*: and as to the *materials*, we could not perceive any *diversity*, whether the *Cups* were of *Glass*, *Earth*, *Wood*, *Metal*, or precious *Stones*. But as to the *Figure*, it seemed to us, that whereas in *Beer-glasses*, and all other tall, narrow Vessels, the *smoak* began above,

Aequarzente.

Bicchieri.

above, on the contrary in wide *bouls* it ſmoaked from the *bottom* freely upwards for a ſhort ſpace. *Tazze Sparſe.*

In a *Golden Boul*, we obſerved an *effect* which ought to be *Univerſal* in all Veſſels, tho it is leſs obſervable in ſome by reaſon of their *ſhape:* it was this; when the *ſmoak* ceaſed, that cruſt of *Ice* began to let fall after the manner of dew, a fine *Ice*, like poudered Glaſs, and continued till the *ice* in the Boul being diſſolved, that thin outward covering likewiſe melted.

The *Exhalation* ſaid to proceed from the *ice* ſeems very different from that of any *combuſtible* Matter, and much reſembles the Morning *miſts* that riſe from the *Earth*.

The Ninth Experiment.

Of Reflected Cold.

WE were willing to try, if a *Concave* Glaſs ſet before a *maſs* of 500 *l.* of *Ice* made any ſenſible *repercuſſion* of *Cold* upon a very nice *Thermometer* of 400 *deg.* placed in its *Focus*. The truth is, it immediatly began to ſubſide, but by reaſon of the nearneſs of the *Ice*, 'twas doubtful, whether the *direct*, or *reflected* rays of *Cold* were more *Efficacious:* upon this account, we thought of covering the *glaſs*, and (whatever may be the cauſe) the *Spirit of Wine* did indeed preſently begin to riſe; for all this we dare not be poſitive; but there might be ſome other cauſe thereof, beſides the want of the *reflection* from the Glaſs; ſince we were deficient in making all the *Trials* neceſſary to clear the *Experiment*.

EXPERIMENTS,

Touching an *Effect* of

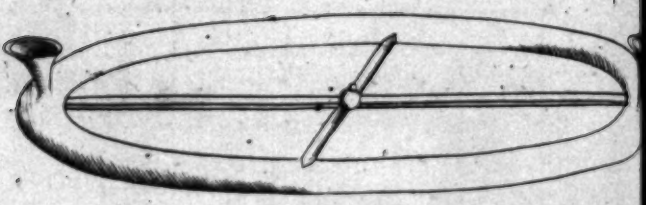
HEAT and *COLD*,

Lately obſerved as to the *Alteration* of the *inward* Capacity of *Glaſs*, and *Metalline* Veſſels.

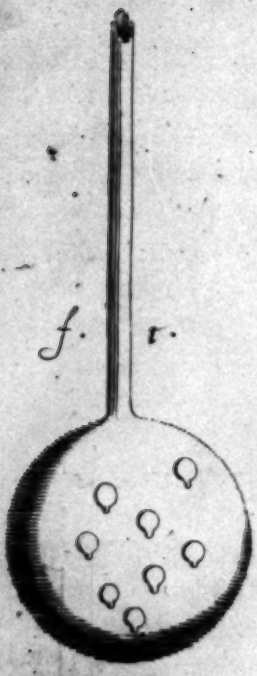
WE ſaid in the *Experiments* of *Artificial Freezing*, that the firſt *Motion* obſerved to be made by the *Liquors* (expoſed in Veſſels to *freeze*) was a ſmall riſing up, there called *Riſe upon Immerſion*; becauſe it happens upon the *Veſſels* firſt touching the *freezing* mixture: and you muſt know, the *contrary* to this is obſervable, when it is immerſed in *hot Water*; for the *Levels* of the contained *Fluids* ſenſibly ſubſide, and then (as it were) take time to Riſe again, which they do with a quick *Spring*, up to the *degree* they ſtood at when firſt immerſed in the *hot* Water, and thence ſucceſſively riſe, as the *heat* received continues to rarifie, lighten, and raiſe them. On the other ſide, tho they are raiſed upon the firſt *immerſion* into *cold* Water, or *ice*, yet they not onely ſubſide again to the former *height*, but continue to do ſo for many Degrees, till at laſt (ſometimes after a little *Reſt*, ſometimes without any) they all *remount* (*Oyl*, and *Spirit of Wine* excepted) until the whole *freezing* is finiſh'd. This *Effect* was by ſome attributed to a *cauſe* much favoured by ſeveral following *Experiments*: their *apprehenſion* was, That the appearance of this *ſudden* motion in *water*, and other *fluids*, was not really from any *intrinſic* alteration of *rarity*, or *denſity* at that moment wrought in their *natural* temperament by the *power* of any contrary

Tab. 15. p. 105.

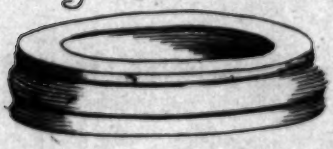
f. 6.



f. 1.



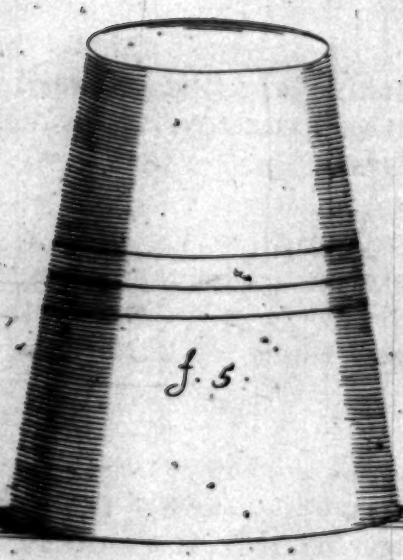
f. 4.



f. 2.

f. 3.

f. 5.



contrary *quality* of the outwardly applyed *ambient*, which ſome by a noted Word call *Antiperiſtaſis*; but rather, (to ſpeak firſt of the ſubſiding upon the *immerſion* of Veſſels in *hot* Water) their thoughts are, that it comes from the *fixing* of ſeveral *volatile* Corpuſcles of the fire, (evaporated from the *hot* Water) into the external *pores* of the *Glaſs*, which as ſo many *wedges*, forcing, and ſeparating the parts thereof, muſt neceſſarily diſtend, and enlarge the *internal* Capacity thereof; till they find a way through the hidden Paſſages of the *Glaſs* to the *Liquor* therein contained. That on the other ſide, *Cold* binding up, and contracting thoſe *pores* of the *Glaſs*, makes the *Veſſel* become too ſcanty for the bulk of Water in it, before that bulk of Water, yet unaffected by the *Cold*, contracts likewiſe. In fine, that the *Veſſel* being firſt ſenſible of *Cold* or *Heat*, by *ſhrinking* or enlarging it ſelf alſo firſt, is the true cauſe of that *Phenomenon* of the *Riſe* or *Fall*; as it becomes more ſtrait, or large to the contained *Liquors*, yet not *vitiated* by the *quality* of the *ambient*. This Opinion was rendred more probable to us; by the following *Experiment*.

An Experiment,

Proving, That in the Inſtant that the External Heat *or* Cold *dilates, or contracts the* veſſel; *yet then the* natural *temperament of the* Liquors *therein contained is* unaltered.

WE included in a *Globe* of Glaſs filled with Water, ſeveral ſmall *bubbles* of *Coloured Glaſs*, empty, and ſealed Hermetically: theſe were all near the *Specifick* gravity of the Water, by means of the *air* they had in them; whence *Tab.* 15. *Fig.* 1. *Smalto.*

whence the *Floaters* upon the top of the *water* upon the leaſt breath of warmth ſunk down, and thoſe at the bottom, upon any acceſſion of *Cold*, mounted upwards: hanging this *Inſtrument* in the *air*, and ſuffering the *bubbles* to reſt, we began to approach to it underneath a *pan* of Water *heated*, and after that of *Cold* Water mix'd with *Ice* well broken; And though upon the *application* of theſe different Ambients, we obſerved the ſame *Effects* in the *Level*, of raiſing it ſelf upon the touch of the *Cold*, and ſubſiding upon that of the *hot* Water; yet we could not find, when the water ſeemed condenſed, and contracted, that any of them at the *bottom* roſe up, nor when the Water ſeemed rarefied, and enlarged, any of the *Floaters* ſunk to the *bottom*: but *theſe* were obſerved to *fall*, and thoſe to *riſe*, when the Water after its abatement upon the firſt impreſſion of *heat*, began to riſe again, and when after its riſing upon the impreſſion of *Cold* it began to ſubſide again: an *argument* to inſinuate, that, the *water*, and ſo any other *Fluids* in this firſt Motion, do not really move themſelves, but onely obey the *alteration* of the Veſſels they are contained in.

Yet it may be *objected*, That theſe firſt *alterations* did really proceed from the inward changes of the *Liquors*, which tho diſcernable by the *Eye*, by means of the ſmall Neck of the *veſſel*, yet were not great enough to be diſcerned in changing the *æquilibrium* of the *Bubbles*; of which it may be thought, that, in *that* very inſtant, they began really to move, though in their firſt parting from *Reſt*, the Eye could not perceive it.

To this is *anſwered*, That, the true *Rarifaction*, and the true *Condenſation* of the Water (that is able to make it *riſe* or *fall* ſo very little a ſpace as it does *riſe* or *fall* at the entrance into the *Icey* mixture, or *hot* Water,) is ſufficient to alter the *Æquilibrium* alſo between it, and the *bubbles*, apparently to the *Eye*. And indeed, when the Water really *riſes* or *falls* from a true *Rarifaction* or *Condenſation*, the *bubbles* likewiſe begin correſpondently to move, before ever it comes to the ſame Degree, at which (the ſame *bubbles* remaining immoveable)

moveable) it ſtood at the inſtant of its firſt *immerſion*. Nevertheleſs, the diſcovery of this *Effect* ought not to cauſe in us the leaſt ſcruple of the truth of our *Thermometers*; ſince the whole *contraction* or *dilatation* in Veſſels containing an Ounce and half, at moſt amounts but to a *grane*; whence proportionably how ſmall will that be in Veſſels of a few *granes* content, ſuch as our *Thermometer* of 50 *deg.* which are the moſt convenient, and exact, and upon that account moſt made uſe of to diſcover the *Alterations* of the *Air*?

Now to manifeſt by divers ways, even to *ſenſe*, the Truth of this *Phenomenon*, we made the following *Experiments*: which firſt founded in the *Theory*, are confirmed by the *Effects*.

The Firſt Experiment,

Shewing the Alteration *of the* Size *of a* braſs-Ring *put in the* Fire, *and in* Ice, *its* Figure *ſtill remaining unaltered.*

THere was ordered to be caſt a *Ring* of *Braſs*, and by turning it was fitted exactly to a *Cilinder* of the ſame *Metal:* this was put in the *fire* for a ſhort ſpace, and then being put upon the *Cilinder* while hot, it was ſenſibly looſe; being dilated by the *heat* into a *Ring* of the ſame ſhape it was of before, but its *concavity* was $\frac{2}{100}$ parts larger: when it had remained ſome time upon the *Cilinder*, and had communicated its *heat* thereto, between the *increaſing* of that, and the ſhrinking of the *Ring* by little and little as it cooled; they not onely came to fit as at firſt, but were ſo firmly united, that before they were quite *cold*, a conſiderable force was but requiſite to ſeparate them.

Armilla di Bronzo. *Tab.* 15. *Fig.* 2, & 3.

The

The contrary in all reſpects happened when we intenſly *froze* the *Ring*.

The Second Experiment,

Whereby it appears that Bodies *are* dilated *by the* imbibing *of* moiſture, *as well as by the* inſinuation *of* heat.

Tab. 15. *Fig.* 4. *Fig.* 5. WE made a *Conical Ring* of *Box*, whoſe concave *Superficies* was curiouſly turned, and poliſh'd: there was alſo made a *ſtock* or Conical *Mandril* of *Steel* turned, and well ſmoothed, and nicely divided with many *circles Parallel* to the *Baſe*: fitting the *Ring* upon *this*, we marked which of thoſe *Circles* the bottom thereof juſt touched; taking it off, we let it lye in *Water* three whole days; that it might have time to penetrate through the whole *ſtubſtance* of the *Wood*; then we put it on again, and obſerved, that the *Concavity* was ſtretch'd, the *bottom* of the *Ring* falling much lower upon the *ſtock*, than it did at firſt.

This *Ring* was made two ſeveral ways, in one the Ligneous *Fibres* were *Perpendicular*, in the other *Parallel* to the *Plane* of the *Baſis*; the firſt after ſoaking in the *water* kept its *ſpherical* Figure exactly, the other came near to an *Oval*, and put upon the *ſtock* ſunk down much ſhort of the former.

Obſerve to make theſe *Rings* of firm, clear Wood, that is without Knots, and of an *uniform* hardneſs; eſpecially, when the *Fibres* are cut *tranſverſly*; that ſo all being ſwell'd by the ſteeping, their *enlargment* may be the more ſenſible. *Note* alſo, (as was ſaid at firſt) that the *Rings* muſt lie ſo long in the *Water*, as their whole *ſubſtance* may be penetrated: for the *Effect* will be different; if thoſe that are but a little

ſoaked

ſoaked on the *outſide*, be put upon the *Stock*; becauſe they will not ſlide down ſo far, as when they were dry. Therefore let them be well impregnated, and ſatiated with *moiſture*, that their *dilatation* may be the more viſible.

The Third Experiment,

Which diſcovers more evidently the readineſs of Glaſs *to* contract *and* dilate *it ſelf upon* Heat *and* Cold.

THere was made a hollow *Ring* of *Glaſs* (as in the Figure) about Two Foot in *Diameter*, with Two *Funnels*, that when the *Liquor* was poured in at one, the *Air* might have vent at the other: then was made a *Croſs* of *Glaſs* juſt to touch with its Extremities the *Concave* of our *hollow Ring*, and filling the Veſſel with *hot Water* by the *Funnel*, as it proceeded in *dilating* it ſelf; ſo viſibly, either the one, or the other of the *Glaſs Rods* loſt their hold; for they did not bear equally ſtiff againſt the *Inſtrument*, and at laſt both were looſened; ſo that the *Croſs* being at liberty, fell down upon the *Table* whereon we ſet the *Inſtrument*, within the *Circumference* of the *Ring*. After this, pouring the *hot Water* out, we fill'd it with a mixture of *Salt* and *Ice* diſſolved; and it not only held the *Croſs* again, but with greater firmneſs than at firſt.

Tab. 15. *Fig.* 6. 1 *Brac.* *Ciambella.*

The Fourth Experiment,

To find the same Effect *in* Metals.

Stagno. Tab. 16. *Fig.* 1. HAving bent a small Plate of *Tin* like a *Stirrup*, and hung it up, so as the two *Extremities* might touch a *Plane* put under them, upon which we drew two Lines, where the aforenamed *Extremities* must necessarily strike, if they had been prolonged: we then put a live Cole over the bending of the *Plate*, and attentively observing one of the *Points*, we discerned, that by little and little it parted from the *line* drawing within it; and this was when the *convex* of the *Plate* onely being heated, dilated it self, and the *Concave* was contracted: but when it had penetrated (which it soon did) the whole thickness of the *Tin*, being then equally *dilated*, the *point* not onely again reacht the Line, but passed beyond it, more or less in Proportion to the *Heat* communicated by the Fire to the bending of the *Stirrup*.

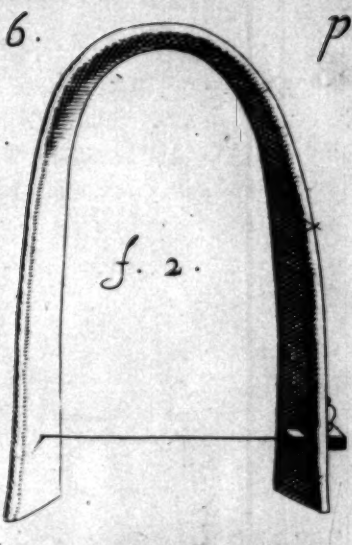
The Fifth Experiment,

To observe by the Sound *the like Dilatation in a* Stirrup *of* Glass.

Minugia. Tab. 16. *Fig.* 2. WE fitted a *Minikin* to a broad *Stirrup* of *Glass*, as in the *Figure*, and tuned it an *Octave* to the string of a *Guitarre*, and applying the *heat* to it after the same manner, as we did to the *Stirrup* of *Tin*, when it had not yet affected the *Concave Superficies* thereof, but onely the *Convex*,

Tab. 16. p. 110.

f. 3.



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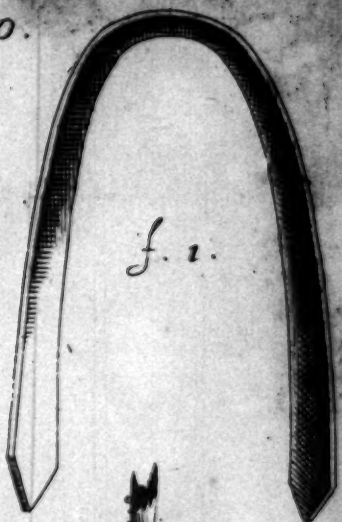
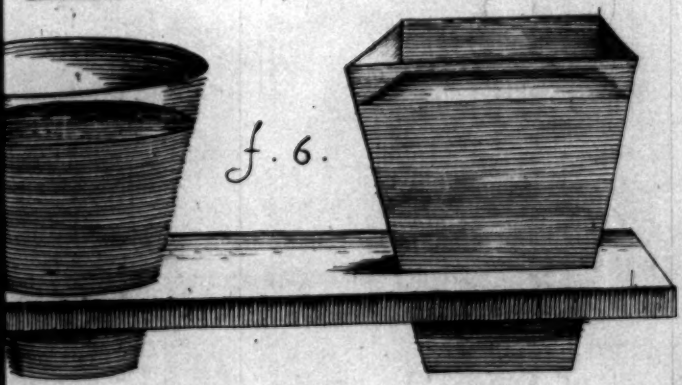


f. 1.



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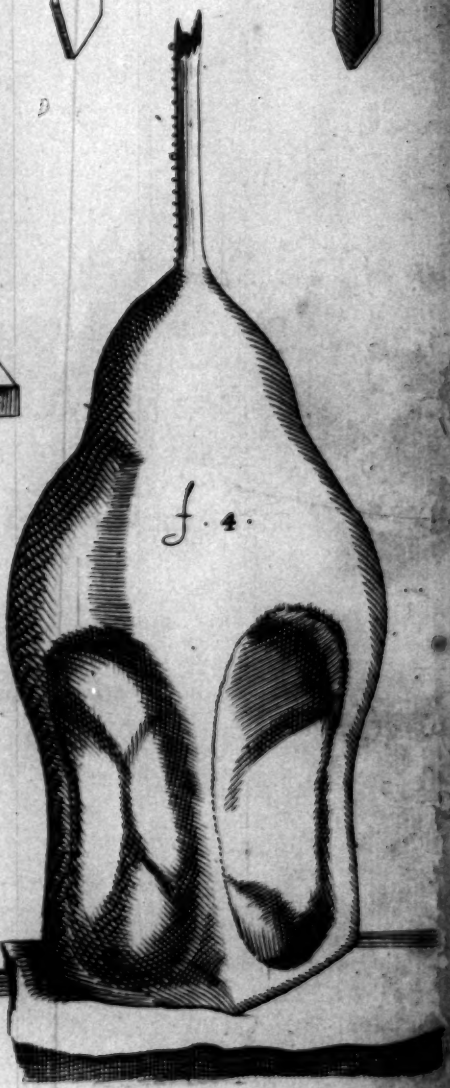
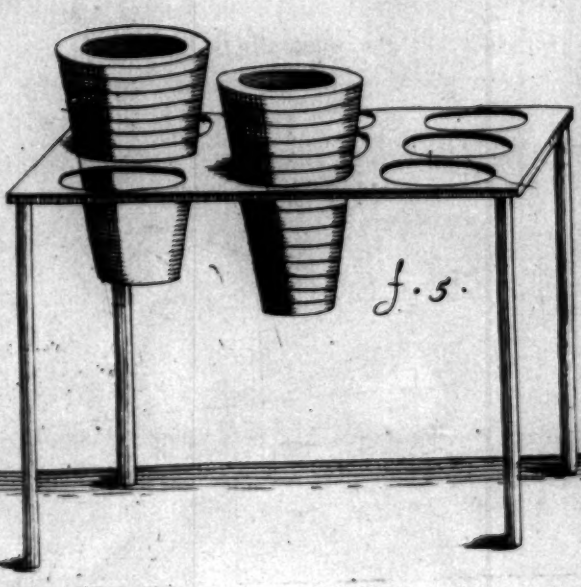


f. 4.



f. 5.

vex, the Tone was flatter, becauſe as in the foregoing *Experiment* the *aperture* was leſſened, and conſequently the *ſtring* ſlackened; but when the *heat* had penetrated quite through, the String was ſtraitned ſo, as the *Sound* was ſharper than the firſt *tuneing*.

The Sixth Experiment,

Diſcovering the ſame Effect *more clearly to the* Eye.

WE faſtned to the ſame *String* with a bit of Thread, a ſmall Leaden *Plummet*, and put under it a little Plate of *Glaſs*, ſo as not quite to touch the Weight; and applyed *fire* to the uſual place: the *Effect* as to the *ſtirrup* was the very ſame as at other times; for being at firſt drawn together, the *Cord* became ſlacker, and the *Weight* Reſted upon the *plate* of *Glaſs*; but at laſt extending the *Aperture*, it ſtrained the *Cord*, and raiſed up the *Plummet*; the contrary *Effect* was wrought by *Ice* made uſe of inſtead of the *Coal*, but ſenſibly leſs, in proportion as its *activity* is leſs; than the *fires*. *Tab.* 16. *Fig.* 3.

The Seventh Experiment,

Shewing the ſame effects *in* Wire ſtrings. *Minugie.*

A Leaden *Plummet* being faſtened to a nealed *Braſs-Wire*, and hung over a Glaſs Plate, at a little diſtance therefrom, drew nearer to touch it as the *Wire* became heated, *Rame Ricotto.*

ted, by applying a lighted *Candle* to it, and ſtill retired from it upon every little Rubbing with *Ice.*

Ottone. In like manner, two *wires* of *mixt braſs* tuned *uniſons*, ſo that one being ſtruck, the other ſounded, were made *diſcordant*, either by approaching to one of them a live *Coale*, or a *piece* of *Ice*, *that* by lengthening the *wire* made the Tone flatter; and *this* by ſhortning it, ſharpened the Sound thereof.

The Eighth Experiment,

Whereby from the appearance *of a contrary* Effect *'tis confirmed, That the firſt Motion of* Liquors *comes from the* Capacity *of the* Veſſels *being altered in the inſtant of* Immerſion.

IT may happen upon the firſt *Immerſion* of Veſſels into the *Ambient* Hot or Cold Body, that the *Level* of the contained Liquors ſhews a different Effect from that before-named; that is, That it may immediatly riſe in a *hot Ambient*, and ſubſide in a *Cold* one: this will be always if the *Tab.* 16. *Fig.* 4. Veſſel be made in the ſhape repreſented by the Figure; in this upon the firſt touch of warm Water, the *Liquors* will preſently Riſe, becauſe (in the *lateral Angles*, being very ſtrong and thick of *Metal* in compariſon of the hollowed *faces*,) the *heat* acting, firſt upon the outward *Superficies*, leſſens thoſe *Angles* (as we ſaid before it does to the *Stirrup* of *Glaſs*) and ſo neceſſarily comes to ſtretch the thinner hollowed parts, which Dilating inwards, happen at firſt to leſſen the *Capacity* of the Veſſel, and to raiſe the Liquor in the Neck: which falls again from that ſpace new filled, when the *heat* has penetrated the whole ſubſtance of the *Glaſs*, and the Veſſel begins to enlarge it ſelf uniformly, returning to its firſt ſize, and larger; and at laſt the *Liquor* Riſes

Riſes again, when impregnated with the fiery *corpuſcels* it begins to Rarifie. And it is manifeſt, that the contrary to this, is obſerved from *Cold*, the ſame cauſes acting contrarily. And *Note*, That the *Capacity* of the *Veſſel* was leſſened, by the preſſure of the Hand onely, made upon two oppoſite hollow ſides; nor could the Riſing of the *Liquor* be attributed to the *heat* of the Hand Rarifying it; for it was raiſed after the ſame manner, by preſſing the *Veſſel* with two pieces of *Ice*.

The uſe of the next *Inſtrument* may eaſily be comprehended from its *Figure*; being onely a Plate of *Steel*, perforated with Circles of divers *Meaſures* to obſerve the different increaſings, cauſed by different Degrees of *Heat* given to the ſame, or ſeveral *Conical* Rings of *Metal*. *Tab.* 16. *Fig.* 5.

The Ninth Experiment,

To ſhew, That a Veſſel *may be diſtended, not onely by* Heat, *or by ſoaking up of* moiſture, *but alſo by* Weight.

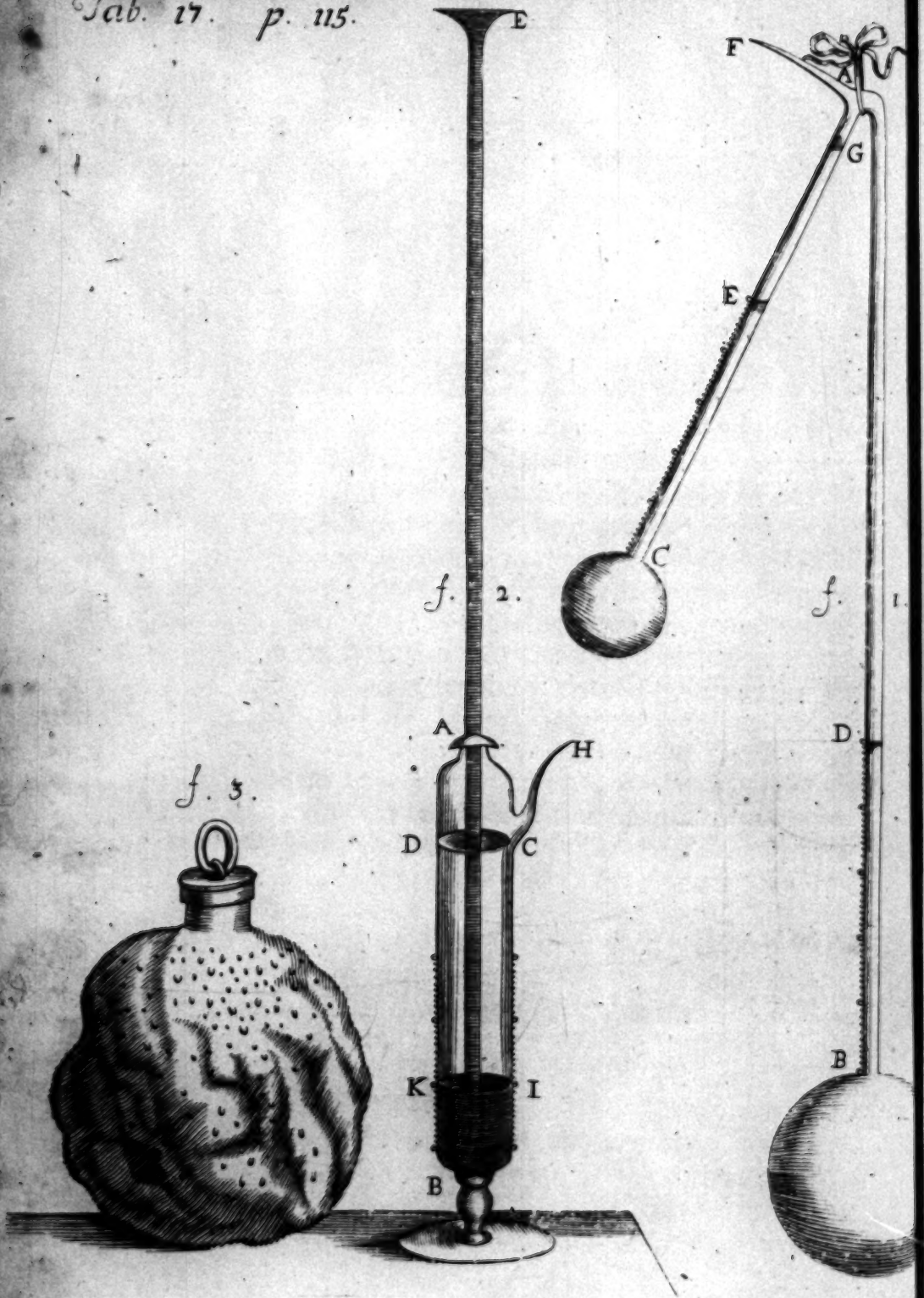
THere were made Two *Veſſels* of *Glaſs*, the one *Conical*, the other *Pyramidal*; and letting them into a thick *Table*, we marked round the outſide of the *Veſſels* how far they ſunk down; then taking them out, we fill'd them with *Mercury*, and put them again into the *holes* in the Table; but they would not go down ſo low as the Mark made at firſt, becauſe they were diſtended by the force of the *Mercuries* weight. *Tab.* 16. *Fig.* 6.

EXPERIMENTS
About the
Compreſſion of *Water.*

THat *Experiments* do not always reach the *truth* aimed at, is not from any defect of the *Idea* conceived of them in the *mind*; but rather happens from the neceſſity we have of *material* Bodies, and *corruptible* Inſtruments, to put our Conceptions in *Practice*; which though of themſelves unable to blemiſh the *Theory* and *Speculative* part, yet through the Defaults in their *ſubſtances*, are not always capable of ſeconding our thoughts: but we muſt not hence conclude, the *Experimental* Method fallacious in the Queſt of *Natural* Events: for though by it we may ſometimes come ſhort of the very depth of that *Truth*, which we firſt ſought after; yet it is hard, if it does not give ſome *glimmerings* and *marks* to diſcover the *falſity* of any contrary *ſuppoſition*. This has been our *Fate* in our *Reſearch*, Whether *water* can ſuffer any Compreſſion, as *air* does; in which attempt, for as much as the weakneſs of our Veſſels came ſhort of affording us a perfect knowledge of the *Truth*, we making uſe of *Glaſs* ones as moſt fit, becauſe of their *Tranſparency*; yet at leaſt we gained this much, that *Water* cannot be compreſſed with a very great *force*; and ſo far we have proceeded, That a power able to reduce *Air* into a ſpace 30 times leſs than what it firſt filled, that power not onely *thirty* times, but a *hundred*, nay perchance a *Thouſand* times encreaſed, was too weak to compreſs a quantity of Water a Hairs breadth, or the leaſt viſible Space from its Natural *Extent*; the Methods we took were thoſe that follow.

The

Tab. 17. p. 115.



The Firſt Experiment.

LEt there be at the Ends of Two Glaſs Canes A B, A C; two balls of Glaſs alſo, the one larger than the other; *Tab.* 17. *Fig.* 1. fill both with fair *water* to D, and E, and joyn them together with a *Lamp*, remembring to leave a paſſage open in ſealing them at A, and to draw the beak A F very long, and open; then apply to each Ball a Glaſs full of beaten *Ice*, burying them therein, that by condenſing the *water* there may enter as much *air* as poſſible into the Canes; and the better to force it down, you may rub a piece of *Ice* backward and forward upon the out-ſide of the *Syphon* DAE, which by its Coldneſs contracting the *air* in the Canes, there will enter in more to fill it at the Beak F; then Seal it at a Flame, and the contained *Air* will remain preſt and thronged together; after this as it is Sealed, take the Ball B out of the *Ice*, and at firſt immerſe it in *tepid Water*, next in *warm*, and at laſt in *boiling*; keeping the Ball C all the while covered with *Ice*, to reduce the Water therein to the utmoſt *condenſation*, which ſuppoſe to be at E; moreover, indeavour to compreſs the *Cilinder* of *Air* G E to its greateſt *denſity* by the force of the Water riſing to G, being Rarified by the received *heat* from the Water ſuppoſed to *boile* round about the *Ball* B; now if the Water could ſuffer any Compreſſion, it ought to ſubſide from the preſſing *Air* below the Mark E; but with us it ſtill happened otherwiſe; for when the Water at E was once reduc'd to its utmoſt Condenſation by the *Cold*, &c. the force of the *Air* G E preſſing thereon, was unable to gain a *Tittle*, and did ſooner burſt out the bottom of the Ball C, than force the *Level* E a jot; and when to add a greater ſtrength to the *Inſtrument* we made the two *Rame.* Balls of *Copper*, the Water in the *Ball* C has ſuſtained the Force between the *Air* preſſing at E, and *Solidity* of the *Metal*

Metal with inſuperable Reſiſtance, rather burſting the *Syphon*, (which muſt be of *Glaſs* to diſcover the Internal Motion of the Water) joyned faſt to the *Copper* with *Maſtick*, or the uſual hard *Cement*.

The Second Experiment.

Tab. 17. *Fig.* 2. LEt there be prepared a Veſſel of *Glaſs* A B, contained about 6 *l.* of Water, the Mouth large enough to receive a Glaſs *Cane* bound cloſe about with *Lead* to keep it from burſting: fill this Veſſel with Water up to C D, immerſed the *Cane* E F open at each end therein, and Soder it cloſe at A with the uſual Cement, remembring to lift up the lower End a little from the bottom of the Veſſel F B, that the *Liquor* poured thereinto, may have free paſſage into the Veſſel: then begin to pour *Quick ſilver* down the *Cane* into the Veſſel, raiſing up the *water*, till the Veſſel is quite full (the *air* having its *exit* at the Beak H) and to be certain all the *air* is gone, let ſome Water out at the Beak H, and immediately Seal it with a Flame; noting, at the ſame time, the Degree the *Mercury* ſtands at in the Veſſel I K: afterwards, pouring in more *Mercury*, fill the *Cane* to the Top; then if the Water by this force is compreſſed, the height I K will gradually encreaſe, as the Water yields: we *Brac.* 4. by a *charge* of 80 *l.* of *Mercury*, in a *Cane* above 91 Inches long (for ſo much our *Inſtrument* held without cracking) could not perceive the *Level* I K raiſed an Hairs breadth, the Water obſtinately reſiſting the force of ſo great a *momentum*.

The

The Third Experiment.

WE ordered a thin large Veſſel of *Silver* to be caſt, and filled it with Water cooled very well with *Ice*, and ſcrewed the Cover on with a very cloſe Screw; then we began to hammer the Veſſel gently every where, and the battered Silver (which being ſo little *Ductile* did not at all thin, and diſtend it ſelf, as refin'd *Gold*, *Lead*, and other ſoft *Metals* do) leſſened, and compreſt the inward *Capacity* of the Veſſel by Degrees; yet the Water for all this ſuffered not the leaſt *Compreſſion*; for at every ſtroak we perceived it to ſweat through the Veſſel at all the little Pores of the *Metal*, as *Quick-ſilver* when preſſed with a piece of Leather ſpirts through in little drops. *Tab.* 17. *Fig.* 3.

This is what we thought worth relating of theſe three *Experiments*; but are not yet able to ſay, whether, if the ſame *Experiments* be repeated in Veſſels of greater ſtrength, and if the *Rarefaction* of the Water be Augmented in the *firſt* Experiment, and ſo the Preſſure of the *Air*; or if the height of the *Mercurial Cilinder* be increaſed in the *ſecond*; or if in the *laſt*, the Veſſel be ſucceſſively made of thicker *Silver*; I ſay, we are not poſitive, whether the *water* may not at laſt happen to be compreſt; this is certain, That *Water* in compariſon of *air* reſiſts the *Compreſſion* (we may almoſt ſay infinitely) more: which confirms what we ſaid at the beginning of theſe *Experiments*, That if *Experience* does not reach the very bottom of the enquired *Truth*, yet it goes hard if it ſtrikes not out ſome Light.

EXPERIMENTS

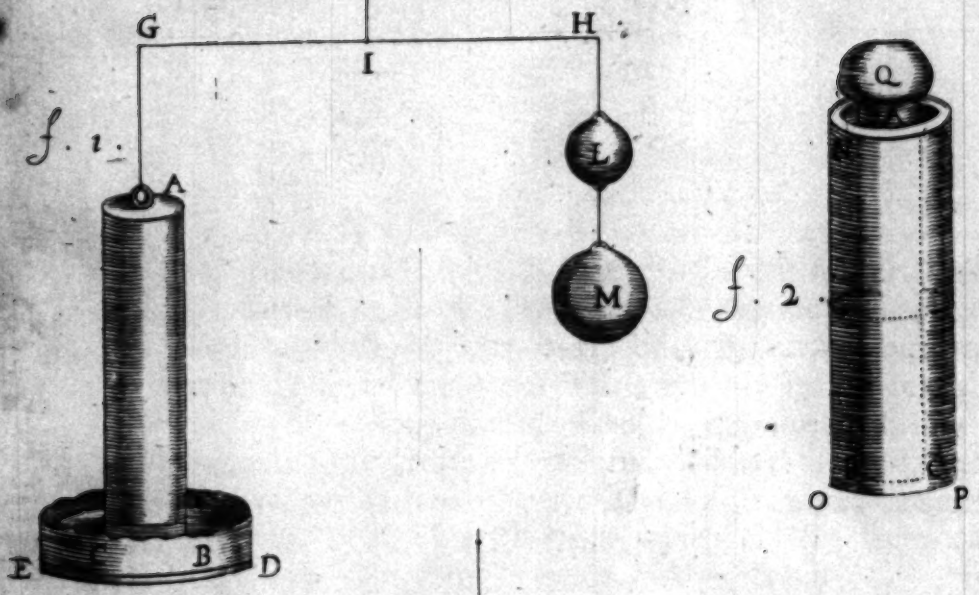
To prove there is no

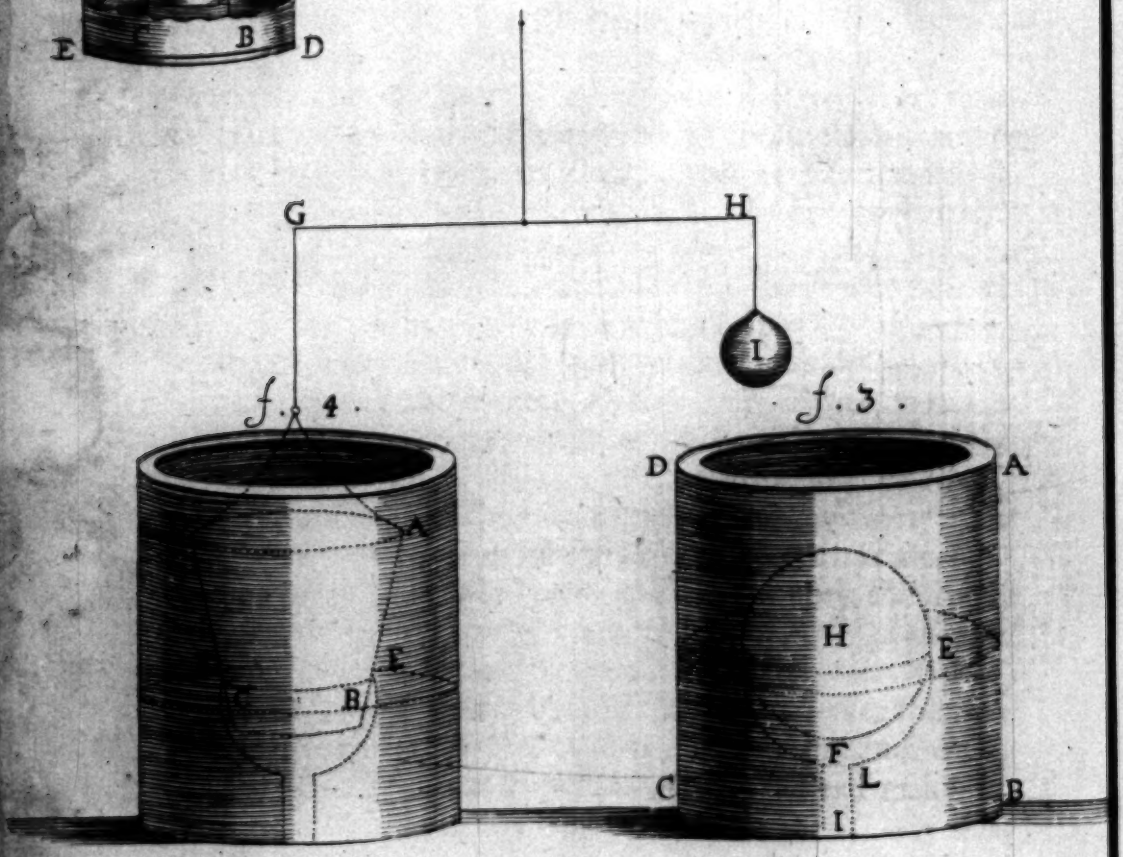
Positive Levity.

ANcient, and Famous is that *Question*, Whether those *Bodies* that we usually call *Light*, are so really in their own *Nature*, and mount upwards from any proper tendency; or whether their Motion be no other than a chase, or flight they are forced to by more *heavy Bodies*; which having the greater force, and desire to descend, and place themselves undermost; press, and as it were, compel the *other* to rise? This Opinion, which chiefly seems to have been entertained in these *latter* Ages, was yet not unknown to the *Ancients*: Nay, it was Asserted from rational grounds by many *Philosophers* in those times; among the rest clearly by *Plato* in *Timæo*; and he advanced so far upon the probability of that *thought*, that he not onely holds, That the *heavier Bodies* force up the *less heavy*, as *Fire* does *Air*: but also the *more heavy*, as *Water* in respect of *Air*, when ever it is made *lighter* by the interspersion of *Fiery* Particles: and this he seems designedly to insinuate in the above-cited *Dialogue* of *Timæus*, when he says, That the *fire* rising from the hot Entrails of the *Earth*, and not entring into a *Vacuity*, thrusts forward the *Air* that is contiguous to it; which not onely gives way thereto, but even divests it of those moist *Particles* wherewith it ascends; and then helps it forward, and raises it up unto the seat of *fire*, and that by no other, than by the natural *gravity* of those *humid* parts, being (by means of the *Coalition* with it) attempered by the new acquired *Levity*: however this may be, in confirmation of this *Opinion*, we will produce onely Two *Experiments*, whose *weight* may perchance make up the *deficiency* of their *Number*.

The

Tab. 18. p. 119.





The Firſt Experiment.

LET there be a *Cilinder* of Wood A B C, whoſe *baſe* B C exactly touches the *Horizontal* Plane D E; and that the Ambient *air* getting between the Two *Superficies's*, may not hinder the trueneſs of their *Contact*, let the *Baſe* of the *Cilinder* be lined with a Plate of Metal plained, and well poliſh'd, and another like piece Leaded into the *Horizontal Plane*, then making a Ridge with *Wax*, or *Plaiſter* round about the *Cilinder*, pour *Mercury* into the *Trench* up to F, that the Contact may be every way covered and hindered from the ingreſs of the *air*: Then faſten the end of the *Cilinder* A to one of the equal Arms of a *Beam* G H, whoſe *Center* is I; at the other End H, hang the weight L, equal to that of the *Cilinder* A B C: it is manifeſt to ſenſe, that to raiſe the *Cilinder* from the *Plane*, the Weight L is inſufficient, but ſeveral weights muſt be added to the End H, till at laſt (ſuppoſe) L and M raiſe it, reſiſting now with a double *force*; that is, with that of its own weight equal to L, and with that of the *Contact*, or *Repugnance* to *Vacuity*, or what elſe it may be termed. The Superadded weight M muſt not onely *equal*, but *exceed* the *power* of the ſaid Superficial *Contact*. *Tab.* 18. *Fig.* 1.

To meaſure this *force* (which in our *Inſtrument* was about 3 *l.*) put the *Cilinder* into a *Cilindrical* Veſſel of Wood, or Potters Clay glazed N O P, of an equal, or greater height therewith, that the *Baſe* of the *Cilinder* may touch exactly the *Plane* of the Veſſels *bottom*; let that alſo be covered with a poliſh'd *Metal* or ground *Glaſs*. Then pour *Quickſilver* into the Veſſel N P, to what height you pleaſe, even to the Top of the *Cilinder*, which will never ſeparate it from the bottom; but if with the hand you move the *Baſe* B C *Tab.* 18. *Fig.* 2.

from the Plane O P, it will with great force riſe up, and ſwim upon the *Quick ſilver*.

Seek then how great this Raiſing power is, ſuppoſed to proceed from *lightneſs*; by us 'twas ſo found: we loaded the Top of the *Cilinder* A with ſo much Weight Q as would ſink it to the *bottom*: which Weight in our *Experiment* being about 5 *l.* we concluded, the *force* enquired to be ſo much: Next we conſidered, That the Reſiſtance of the *Contact* of the *Superficies's* was no more than 3 *l.* (as was ſaid) and the *force* of the ſuppoſed *Levity* of the *Cilinder* was found to be 5 *l*: wherefore in this caſe, that of the *Levity* was more than that of the *Contact*: wherefore again, conſidering the *Cilinder* of Wood A B cloſed down with its *Baſe* B C to the *Plane* O P, there were then *two* contrary Powers acting; *viz.* That of 5 *l.* from the *Levity* to raiſe it; and that of 3 *l.* from the *Contact* which held it down: now the *leſſer* force ought to yield to the *greater*, and ſo the *Cilinder* be raiſed: but it was not ſo here; for the *Contact* was not looſed: wherefore it ſeems we muſt conclude ſomething beſides *Levity* buoyed it up.

The Second Experiment.

Tab. 18. *Fig.* 3. LET there be a Wooden Veſſel ABCD, in the thickneſs of the *Bottom* whereof a Concave *Hemiſphere* is turned E F G, exactly fitting a Ball of *Ivory* H, adapted to its greateſt *circle* E G; then the whole Veſſel was filled with *Mercury*, ſo that the Globe was quite covered therewith; it is manifeſt, that the weight of the *Mercury* incumbent upon the *bottom* of the Veſſel, and hindred from running between the lower Convex of the *Ball*, and *Concave* of the Veſſel by the cloſeneſs of the *Contact* at the *circumference* E G, was not able by deſcending thither to raiſe the *Ball* by pulſion, but the Natural *Levity* of the *Ivory*, if there be any

any such thing, might easily buoy it up in the *heavy* Ambient of the *Quick-silver*. But this did not follow; the *Ball* remaining unmoved in its *socket* under any height of *Mercury*.

Nor can it be objected, That Natures avoiding a *Vacuum* (which must follow upon the first loosening of the *Ball* from the *concave* of the Vessel) hindred the Natural *Levity* of the *Ball* from its *Effect*; for though we made an *hole* thorough the bottom of the Vessel F I, whereby the *air* had admission to fill the space left void upon severing the *Ball*; yet for all this it was not raised.

And because it may be said, That the *Ball* being touched by the *air* below, is not *lighter*, but *heavier* than it; we again stop'd up the *hole*, and enlarged the *Socket* (as it appears) E L G, so that onely the *Edge*, or upper *circle* of the *hole* E G remained equal to the greatest *circle* of the *Ball*; but the *Hemisphere* E F G was not now fitted to the *concave* E L G, as is plain in the *Figure*: we then filled E L G with *Mercury*, and forcibly thrust down the *Ball* till its greatest *circle* touch'd the Edge of the *concave*: now tho it was but slightly held by the Circle E G, so that with a very little *force* it might be turned about; yet we fill'd up the Vessel with *Mercury*, and it was not raised, nor moved.

Lastly, That it might not be suspected, that the *Mercury* poured on, by pressing upon the *Ball*, held it down with its weight from swiming; we took instead of the *Ball* H a *Conical* Glass Vessel A B C D, and fitted a lesser *circle* thereof to the Edge E F, and pouring *Mercury* round about it, it kept still unmoved: and to be satisfied, if the supposed tenacious *Union* between the *Glass*, and the *Mercury*, together with Natures *fuga vacui*, were able to surpass the *power* of the Glasses *Levity*; we tryed the force of that *Contact* by taking away the *Mercury* from about the *Glass*, and fastening of it to the one *Terminus* of an equal Ballance G H, hanging a weight I at the other H, till the *glass* was loosened from the *Socket* E F, which weight was with us about a Pound: then filling the Vessel again with *Mercury*, we set *Tab.* 18. *Fig.* 4.

the

the *Glaſs* to ſwim therein, and loaded it (as in the other *Experiment*) 'till it ſunk it to the bottom, and kept it there: this Weight (which with us was about 2½ *l.*) may be the true meaſure of the *momentum*, believed to proceed from the *Levity* of the Glaſs A B C D, which is more than that whereby it reſiſted a *vacuity* which was but one Pound. Then if the *Lightneſs* is that which cauſes the *Glaſs* to ſwim, it would have produced its Effect, diſſolving the *Contact*, ſince its *force is* much greater than that of the *Contact* reſiſting it: but it does not do it; therefore it ſeems, that the ſame is confirmed by this Second *Experiment*, which was concluded from the *former*, *viz.* That it is ſome other Cauſe beſides the *Levity*, that lifts up the *Ivory* Ball, and the *Glaſs* Veſſel.

Experiments,

EXPERIMENTS

Magnetical.

ALtho the ſtrange *Effects* of the *Magnet* are ſo boundleſs an *Ocean*, that tho many Diſcoveries have been made thereon; yet 'tis probable, enough remains to ſatisfie the *Labour* and Curioſity of future *Adventures:* yet we have not hitherto been ſo hardy to launch forth into it; well knowing, that any thing *new* therein, requires a long application, and uninterrupted by other *ſpeculations:* wherefore we would not have it thought by any, that with two or three Obſervations upon this *Subject*, we ſhould be ſo vain to boaſt, that we have brought any *Light* to the *Magnetic Philoſophy*; for we rather own, that theſe *hints* are mean enough, and it may be not altogether *new*, being ſuch as have not been aimed at in a deſigned Application of our *Endeavours Magnetical*; but either have been *accidentally* found out, or ſought after upon ſome particular end by ſome one of our *Academy*. But ſuch as they are, we were unwilling to conceal them; our intent being to communicate all that has any agreement with Truth, tho of but little Value.

The

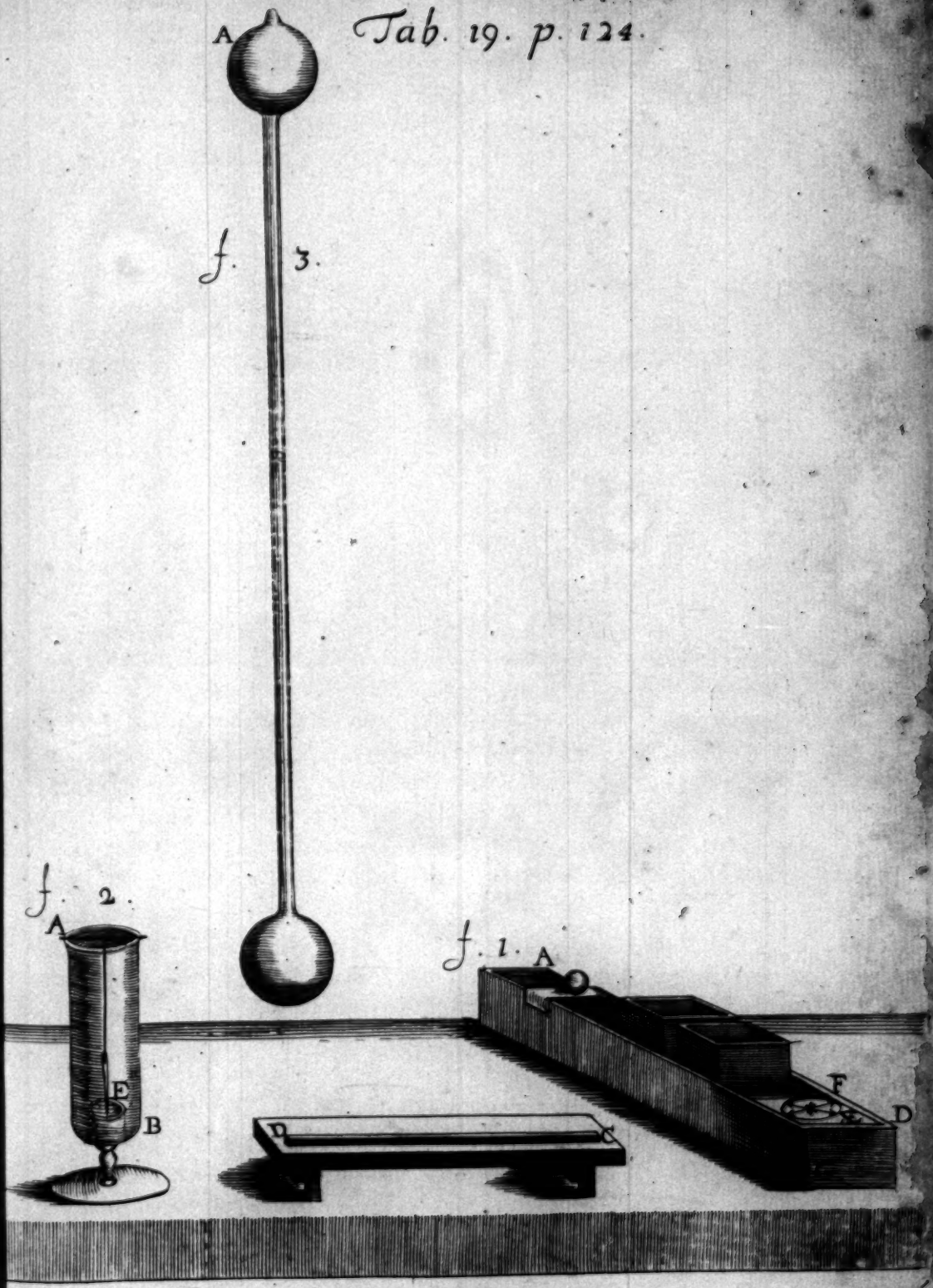
The First Experiment,

To discover if (*except* Iron *or* Steel) *there be any* Solid, *or* Fluid *Body, which interposed between the* Magnet *and* Iron, *will cause any* variation, *or quite cut off the Passage to the* Magnetic *Virtue.*

Tab. 19. *Fig.* 1. AT one end of a Wooden *Box* A B C D, we fixt a *Compass*, and opposite to the *Dart* (respecting the point E) at the other end of the *Box*, we moved a *Magnet*, and gently approaching it nearer till the *Dart* was removed one Degree, that is, from E, to F, we there fixt the *Load-stone*, and in the space remaining between it, and the *Compass*, we set either *glasses* filled with *Mercury*, or *Wooden* Vessels filled with *Sand*, or *Fileings* of *Metal*, (except of *Iron*, or *Steel*) or solid *Parallelipipid's* of the same *Metal*, or of divers *Stones*, and *Marbles*; but still we found the *Dart* unmoved from the Point F. Lastly, we filled the same Vessels with *Spirit of Wine*, and set it on fire, yet that *Flame* did not in the least divert the *Power* attracting the *Dart* to F: and a thin Plate of *Iron* or *Steel*, onely was able to vary it, and make it return to E, as is already known. And not onely the above-named Causes were unable to obstruct the *Magnetic Activity*; but we have laid upon one another 50 pieces of *Gold*, and laid a *Needle* upon the uppermost, which has obeyed the Motion of a *Magnet*, moved under the lowermost.

The

Tab. 19. p. 124.



The Second Experiment,

To ſhew yet more nicely, Whether the Magnetic *Virtue ſuffers any* change *by paſſing through divers* Fluids.

WE hung upon a ſmall *ſtick* croſs a Glaſs Veſſel A B, a Needle touched with a *Loadſtone*, and in the bottom of the Veſſel placed a little *Cilinder* of *Lead*; upon the upper *Surface* thereof we fix'd two Points of *Braſs*, (they may be of any *metal* but *Iron*) one placed in the *Center*, the other the *breadth* of a *Crown* off it; then we adjuſted the *Needle* exactly *Perpendicular* to that in the *Center*, and placed the *Magnet* at ſuch a *diſtance*, as not to move it; Then we gently approach'd it toward the Needle, keeping the *Pole* ſtill direct upon it; which to be certain of, we ſlid the *Stone* with one of its ſides along a *Ruler* C D fix'd in a *Frame*, and levell'd exactly upon the Two *Points*, whereof that which was not in the *center* reſpected the *Pole* of the *Magnet*, as well as that which was: coming nearer and nearer, at laſt its *virtue* began to act upon the *Needle*, which ſenſible of it, moved ſoftly toward it. The *Obſerver* did not reſt there, but thruſt the *Loadſtone* a little forwarder very ſlowly, till the Point of the *Needle* reach'd to the Second *braſs Pin*, which was nearer to the *Load-ſtone*: then he ſtop'd, and gave a Mark upon the *Rular*, at the diſtance between the *Magnet* and *Needles* Point, which was juſt over E. After this, the *Magnet* was removed, and *fair* Water poured into the Veſſel about the *Needle*, and the Operation was repeated as before, by approaching the *Stone* gently till the *Needles* Point touch upon E; and again, the Diſtance *Tab.* 19. *Fig.* 2.

upon the *Rular* was marked: and throwing out the Water, 'twas reiterated with ſeveral *fluids*, the Diſtances being taken every time between the Point of the *Needle* and *Magnet*: from all which it appeared, that the *Magnetic* Virtue was neither weakned, nor enforced by the differing *Fluids* through which it paſſed: indeed the *diſtances* were divers, but that happened according as a *lighter* or *heavier medium* facilitated more or leſs the motion of the *Needle* in it; whence the ſame Virtue and Power moved it at a further or nearer Diſtance; for 'twas obſervable, That thoſe *ſeveral* Diſtances at which it acknowledged the *Loadſtone*, were in *reciprocal* Proportion to the *Specific Gravity* of the *Fluids*; that is, to the making the *Needle* lighter. Amongſt all the *Liquors* experimented, the *Needle* was drawn at the greateſt Diſtance in *Sea-water*, at a leſſer in *common-water*, leſſer in *Spirit of Wine*, and leaſt of all in the common *Medium* of *Air*.

Note, That Repeating this *Experiment* at ſeveral *times*, it may happen, that this *Diſtance* varies at one time from another; but it is to be conſidered, That this may ariſe from *External* Accidents, *viz.* the different Temperature of the *Air*, a *ruſtier* or *brighter* Needle, or the fortuitous nearneſs of ſome *Iron*, which makes the *direction* of the *Magnetic Virtue* to deviate ſome way or other, *&c.* Wherefore we ſtill took care to make this *Experiment* upon a large Table glewed together, and faſtned with *wooden Pins* inſtead of *Nailes*: and the *Obſerver* (and every body elſe that came near) was very careful to lay aſide any *Iron* they had about them, it being well known, That to approach the Table with a *Key* or *Knife* in their Pocket, immediatly cauſed an alteration in the *Experiment*; but when all ſort of *Iron* was laid away, the *Effect* was always the ſame: but for what depends upon the other fore-named *accidents*, ſuch as the Temperament of the *Air*, and the like, which cannot be helped; we have found, that they do indeed cauſe ſome *difference* in the *Diſtances*; that is, The *Diſtance* whereat the *Needle* was moved *Yeſterday*, is not the very ſame to *Day*, in the

the ſame *Mediums*; yet the *Differences* obſerved at theſe divers times, were ſtill found nearly *proportionate* to each other.

The Third Experiment,

To try if the Activity *of the* Poles *of a* Magnet *alters, being placed reſpecting the oppoſite* Poles *of the* Earth.

THo in this *Experiment* we have not yet proceeded ſo far, as to ſatisfie in order the many *particulars* depending thereon; yet in general we will touch upon thoſe few which we think we may aver upon any more certain grounds; as theſe: The *North Pole* of the *Magnet* when reſpecting the ſame *Pole* of the *Earth*, draws a *Needle* hung freely in the *Air*, at a greater diſtance, than when it reſpects either the *South*, or *Eaſt*; placed *Weſtward*, its *Sphere* of Activity is larger than *Southward*, and a little leſs than *Northward*.

On the contrary, the *South Pole* not onely ſeems to us, to act at the ſame Diſtance *Southward*, as the *North Pole Northward*; but alſo in a *North* Poſition happened to dra w the ſame as it did when *Southwards*; towards the *Eaſt* or *Weſt* it becomes more faint and languid, as the *North Pole* does alſo.

EXPERIMENTS,

Touching

AMBER, and other *ELECTRIC* BODIES.

THE *Electric* Virtue, as all know, is excited by a ſlight, or violent rubbing in all Subſtances not *Mineral*. *Yellow Amber* is of all others beſt ſtored with this Power: next to which, the beſt *Sealing Wax* ſeems to take place; theſe are followed by *Roſe Diamonds*, the *White Saphire*, the *Emerald*, the *White Topaz*, the *Spinelle*, and the *Ruby Baleis*; after them, are all the Tranſparent *Gems*, as well *White*, as *Coloured*; all which, more or leſs ſhew themſelves to be Attractive.

Ambra Gialla. Cera Lacca. Diamante. Zaffiro Bianco Smeraldo. Topazio Bianco.

And in this it does not ſeem, that they keep any *Scale* or proportion in reſpect of their hardneſs: for we find that the ſoft *Spinelle* and *Ruby balleis*, not at all to give place to the hardeſt *Diamond*, or *Saphir*, in *Electricity*. Next *precious Stones*, come *Glaſs*, *Criſtal*, *Yellow Amber*, and *Black*; between all which Bodies, there is little difference of force, they being all very weak in Operation. For the reſt, neither *Lapis Lazuli*, *Turquoiſe*, *Jaſper*, *Agate*, nor other the like *Precious Stones* not Tranſparent, nor *Rocks*, nor the fineſt *Marble*, nor Marine Bodies, as *Coral*, and *Pearl*, nor *Metals*, nor Criſtalized *Salts*, have any *attractive Virtue*, as ſome have wrote they have; and it may be the miſtake came from their obſerving ſome light Bodies, as bits of *Straw*, and *Paper*, *&c.* ſtick to them, which we have alſo obſerved; but perchance that might happen (as ſome think) from a *Superficial* roughneſs, or inequality in the Subſtances, whoſe Points piercing the *light* Bodies, raiſe them up therewith: willing to avoid this Cheat, we reſolved to attribute

Ambra Bianca e nera.

Lapis Lazzali, Turchine, Diaſpre, Agate, Coralli, Perle, Metalli, Lapilli de Sali.

bute *Electricity* to no *Subſtances*, that after a due *Friction* did not attract thoſe light *Corpuſcles* at ſome ſmall *diſtance*, which we onely found done by the above named.

We have alſo Noted, That whatever *External* accidents alters *Amber* (whether by *heating*, or *freezing*, or *wetting* with any Liquor) the ſame has the like Effect upon *Gems*, and all other *Electrick* Bodies: yet indeed it is more manifeſt in *Amber*, as it is impregnated with a greater Virtue: wherefore omiting all others, we will here onely treat of that.

Amber then, of all ſorts of Bodies preſented to it, refuſes onely to draw *Flame*; altho *Plutarch* ſays, That it does not attract any thing ſteeped in *Oyl*, and *Greaſe*; or as ſome ſay, *Baſilicon*, which we found a miſtake: yet *Smoke* is attracted; and it is very curious to obſerve, how by holding a piece of *Amber* rubbed hot, to the *ſmoak* of a Candle blown out, it will preſently bend, and wave towards the *Amber*; part of it will be arreſted by the *Amber*; and part, as if reflected from a *Glaſs*, will mount upwards, while that which remains, unites it ſelf like a ſmall *Cloud*, and as the *Amber* cools riſes in *ſmoke* again, and vaniſhes. *Saggina.* *Baſſilico.*

On the other ſide, *Flame*, not onely refuſes to yield it ſelf; but if a piece of *Amber*, after it is well rubbed, be a little while held to it, it loſes its Virtue, and a repeated *Friction* is but neceſſary to make it attract; and if after it has taken up any ſmall thing, it be held to the *Flame*, it will immediatly let it go again.

But the Heat that comes from burning Coales, is not ſo great an Enemy to the power of the *Amber*, it being ſometimes capable of exciting it without rubbing, and indeed by the *heat* received from the *Fire* onely, it acts faintly; but then becomes more vigorous, by adding *friction* thereto.

Ice alone is not prejudicial to the *Amber*, but when altered by mingling therewith *Salt*, or *Aqua Vitæ*, it ſo quells the Virtue, that ſome time is required, as likewiſe a long and violent *rubbing*, to regain it. So that it has been thought,

that

that this ſtupifying of its *force* proceeds not from the *increaſe* of Cold in the *Ice*, from the ſprinkling of *Salt*, or *Aqua Vitæ*; but rather from ſome fine *Ruſt*, or hoarineſs, as it were, contracted by the *Amber*, from the *Salt*; or rather indeed, from the imbibing the *Aqua Vitæ*, which is one of the Liquors that deſtroy the *Electricity* of *Amber*.

Neither are all matters capable to draw forth this Virtue from the *Amber*; for being rubbed upon Bodies of a ſmooth *Superficies*, ſuch as *Glaſs*, *Criſtal*, *Ivory*, and poliſh'd *Metals*, or *Gems*, it ſtill continues aſleep, and ſhews no ſign of Life; ſo that it needs ſome ſmall *inequality* and *aſperity* of the *Superficies*; as *Cloath*, *Linen*, and a thouſand other things have, unneceſſary to be named here: and likewiſe *Human Fleſh* excites this Power; but ſome more, ſome leſs: and we have known ſome, that let it be rubbed never ſo long on their hand, yet could not happen to make it attract.

It is commonly believed, That *Amber* attracts the little Bodies to it ſelf; but the Action is indeed *mutual*, not more properly belonging to the *Amber*, than to the Bodies moved, by which alſo it ſelf is attracted; or rather, it applies it ſelf to them: of this we made the *Experiment*; and found, that the *Amber* being hung at liberty by a thread in the *Air*, or counterpois'd upon a Point like a *Magnetical Needle*; when it was rubb'd and heated, made a ſtoop to thoſe little Bodies, which likewiſe *proportionally* preſented themſelves thereto, and readily obey'd its call.

Liquors alſo are ſenſible of this Power of the *Amber*; the ſmalleſt *drops* of which, it attracts, even thoſe of *Mercury*: indeed it is unable to manage them, except very *minute*; whence it ſoon lets them go, after they have been attracted: but when we have preſented it to the *Superficies* of ſtanding *Liquors*, and *Mercury* it ſelf, it did not raiſe up one *drop*; but as it were, made the Level of the *Superficies* ſwell under it; which raiſed it ſelf in a little Bubble toward it, but inverted ſo, as to reſpect it with its pointed part. This Effect may be better obſerved in *Oyl*, or *Balſam*; than other *Fluids*

There

There are ſome *Liquors* wherewith the *Amber* being wetted, after rubbing, draws not; and there are others not producing this *Effect*; they that ſo *act*, are generally all *Natural* Waters, *Diſtilled* Waters, *Wines*, *Vinegar*, *burning* Waters, all *Acids*; the Juces of all *ſharp Fruits*, all Liquors diſtill'd from *Animals*. *Balſames*, and all *Artificial* Liquors, as *Juleps*, *Eſſences*, *Spirits*, and *Oyls* made by *Diſtillation*: on the other hand, theſe are ineffectual; Oyl of *Flints*, *Sallet* Oyl, Oyl of *ſweet Almonds*, and *bitter*, made by *Expreſſion*. *Tallow*, *Fat*; and Laſtly, all *Butter*, whether *ſimple*, or *Perfumed*, with any *Flowers*, *Ambergrice*, or *Muske*; provided unmix'd with *Eſſences* or *Oyles*.

A particular *Effect* has been obſerved in *Diamonds*, whereof the *Roſes* (as we ſaid) are reckon'd among the moſt *Electrick* Gems; but the *Tables* were found ſo *weak*, that they ſeemed ſometimes quite deprived of that *virtue*; and ſome thought that their plain *Superficies* had no part in the *Effect*, ſeeing when the *Diamond* has *depth*, tho ſmooth'd and poliſh'd upon the Wheel, it draws vigorouſly; whereas the flat *Table-Stones*, that are ſhallow, ſuch as are ſet in *Lockets* at the end of Neck-laces, commonly called *Spere*, tho very large, when ſtrongly Rubb'd, will yet not draw; or if they do, 'tis ſo faintly, that you muſt make them touch ſome hairs of the bit of *Paper*, or *Straw*, to make them raiſe it up; yet 'tis not to be doubted, but ſome may be found that have a little force; yet of theſe, we at leaſt were ſo unſucceſsful as to find but few. We indeed had one which by many trials for ſeveral days, we were never able to make attract; but a Year after, deſirous to ſee the ſame tryed again, we took the ſame *Ring* in which the Stone was ſet, and having but ſlightly rubb'd it, as we uſed to do upon the *Cloath*, as ſoon as ever it was held to the bit of *Paper*, it drew it vigorouſly: this ſame Effect was often obſerved with *wonder* by all thoſe that the *year* before had often attempted in vain to make it draw: and on the contrary, (as we ſaid at firſt) the *fauſets* (*i.e.*) thoſe that are ground of their own *Octoedral* Figure, ſeldom or never failed.

Gruppiti Tavole.

In

In fine, ſince *Amber*, and all *Electrick* Bodies have been obſerved to be obſtructed by a very thin *Vail* placed between them, and the thing to be *attracted*; therefore taking a ſheet of *Paper*, we made ſeveral little *Lattices* in it; and the *firſt* of them was covered with a cloſe *Network* of *hair*, another with the *Lint* of a fine *Rag*, a third with a *Leaf* of *Gold*; the ſucceſs was, That the *Electick* Power of the *Amber* did not *penetrate* them.

Experiments,

EXPERIMENTS
ABOUT
Altering the *COLOURS* of ſeveral *FLUIDS.*

THere is nothing more frequent amongſt the *Niceties* of the *Chymiſts*, than their *Fantaſtic* humour of changing *Colours*; we indeed do not profeſſedly meddle therewith; and if any ſuch *Tryals* were made, we were moved thereto, from the occaſion we had of making uſe of ſome *Liquors*, fit to examine the *Qualities* of *Natural Springs*. Concerning which, we will relate the little that came to our Knowledge; again reminding the *Reader*, That by the perfixt Name of *Eſſays*, we would intimate, That we do not preſume, we have examined theſe Matters with all the *Experiments* which may be thought on; but onely barely given ſome *hints* of thoſe things we were moſt inclined to take *pains* about.

The Firſt Experiment,
Of altering Water.

WAter Diſtill'd in a *Leaden* Still, thickens and muddies the *Water* of all *Rivers*, *Baths*, *Fountains*, or *Wells* wherewith it is at any time mix'd; and loſing their *Tranſparency*, they both look *white* like *Whey*; onely *Water* Diſtilled in *Glaſs Veſſels*, and of *Spring Water*, that of the *Condnit* of *Piſa* remains *Limpid* and *Tranſparent*. But all

those *Waters* so muddyed, become clear and pure again by a few drops of strong *Vinegar* shook together with them.

Olio di Tartaro e d'Anici. The same *Waters* are changed by a dropping in of Oyl of *Tartar*, and Oyl of *Anniseeds*, which give the Appearance of a little *white Cloud* higher, or lower, therein; which by shaking, diffuses it self through all the *Liquor*, and inturbidats it. This also is brought to its former *clearness*, by a small *Quantity* of *Spirit* of *Sulphur*, which at first raises a few little *bubbles*.

Sp. di Zolfo.

Note, That all *Waters* indifferently do not become *turbid* by the above-named *Oyls*; and those *Waters* that are not altered by *waters* still'd in *Lead*, are likewise left *Transparent* by Oyl of *Tartar* and *Aniseeds*. Moreover, *inflammable* Waters, Waters still'd in *Glasses*, and *that* of the Conduit of *Pisa*, are not at all changed from their *Natural* clearness; and we find that in *Waters* generally held the *lightest*, *purest*, and *noblest*, the little *cloud* is thinner and higher, which is raised therein; and onely in *heavy* Waters, and those that are impregnated with *Minerals*, or *dreggy*, it thickens it like *Milk*; whence some have pretended to prove *Waters* with some of the above-named *Liquors*; for thereby is discovered the more hidden *Quality* of them, and so their *Goodness* or *Badness* found.

If at any time the *Thickness*, and *Turbidness* of the Water is very great, and not to be Clarifyed by the ordinary *proportion* of *Liquors*, it may be increased by some *drops* still agitating the Water, till you see it become clear.

The

The Second Experiment.

Of Altering Wine.

OYL of *Tartar*, not onely in *Water*, but alſo in *Wine*, produces the ſame Effect; for through its *Natural* cleanſing *Quality* (as is known) it makes a ſeparation in all *Liquors*, of what ever is mix'd with them, from the purer *parts*, by a *ſediment* that it lets fall; whence that which ſhews like a white *Cloud*, higher, or lower in the Water, according to its different *Qualities* and *Weight*, in all ſorts of *White Wines* that we Experimented, appears like a thin Cloud of a *Red Colour*, which by ſhaking the Wine, quits its firſt place, and diſperſes it ſelf uniformly throughout the whole *Body*; it makes no other change in *Red Wines* than a little *Tinging* deeper; eſpecially toward the bottom.

On the contrary, Spirit of *Sulphur* ſhews no *alteration* in the *natural* Tranſparency of the *Wine*; and likewiſe reſtores it to thoſe deprived thereof, by the Oyl of *Tartar*.

The Third Experiment.

Of the Tincture of Roſes.

A *Tincture* of *Red Roſes* (extracted with *Spirit* of *Vitriol*) being mix'd with *Oyl* of *Tartar*, ſhews a fair Green: with a few drops of *Spirit of Sulphur*, it ferments all into a *Vermillion froth*, and at laſt returns to its firſt *Roſe Colour*, without loſing its *ſmell* at all; nor will it be again altered by dropping Oyl of *Tartar* into it. *Tinctura di Roſe roſſe.*

We found the beſt way of getting the Tincture of *Roſes* for this *Experiment*, as follows.

Taking a good handful of dryed *red Roſe-buds*, we cut them, and putting them in a Glaſs, with one Ounce of ſtrong Spirit of *Vitriol*, ſtirred them together for a quarter of an hour, in which time the *Roſes* were well Macerated, and the *Tincture* Extracted; to this muſt be added, at Three or Four times, about half a pound of *Spring Water*, ſtill ſhaking the Glaſs till the very deep Colour of the *Spirit* being Diluted, the Water is all tinged therewith: then we let it ſtand an hour, and ſo obtain a lively and beautiful *Tincture* of *Roſes*. To half an Ounce of this, put Ten or Twelve drops of Oyl of *Tartar*, and afterward as much Spirit of *Sulphur*, which ſuffice to produce the Related Effects.

The Fourth Experiment,

Of the Tincture *of* Saffron.

Safferano WAter tinged with *Saffron*, helped a little with the Tincture of *Roſes*, but not ſo as to loſe its golden Colour, changes *green* with Oyl of *Tartar*, and again *yellow* with Spirit of *Sulphur*.

The Fifth Experiment.

Of Greens.

Verde Giglio. Vinato. WAter Coloured with *Iris Green*, mix'd with Spirit of *Sulphur*, makes a *Purpliſh* Colour, and with Oyl of *Tartar* takes its own again.

This

This Green is a Tincture taken from the Purple *Flower-de-luce*, which prepared with a mixture of *Quick-lime*, gives a pleasant lively *green*, much demanded by *Limners*; then 'tis set to evaporate and dry in Muscle-shells, as shell-*Gold* and *Silver*.

See more fully the ways of making the like *Extracts* in *Antonio Neri*'s Book of the Art of *Glass-Painting*, Printed at *Florence*, 1612, *Lib.* 7o. *cap.* 108, 109, and 110. as likewise, how to take the Lake of any Flower.

The Sixth Experiment.

Of Violet *Colours.*

JUice of *Limons*, Spirit of *Vitriol*, and Spirit of *Sulphur*, change the Violet Colour of *Lacca* to heighten *Gold*, and the Tincture of Blew *Violets*, into a *Vermillion*; which with the Oyl of *Tartar* again, makes a *Purple*: also *Vinegar* gives them a *red* Colour, but 'tis fainter. *Lacca Muffa.*

Experiments

EXPERIMENTS

About

The Motions *of* SOUNDS.

SOund, that Noble *Accident* of the *Air*, keeps so unchangeable a *Tenour* in its Motions, that a *greater* or *lesser impetus* wherewith the *Sonorous* Body produces it, is unable to alter it. This strange *Propriety* of *Sounds* is related by *Gassendus*, who affirms positively, That all *sounds*, whether great or small, pass the same *space* in the same *time*: and he declares, That he had Experimented it in Two *sounds*, the one much louder than the other; that is, one of a *Musket*, and the other of a Piece of *Ordnance*: in repeating this *Experiment*, which we found undoubtedly true, we happen'd to observe some *Particulars* which we did not think fit to conceal, since possibly they may offer something not thought upon by every one; or if thought on, yet all *Persons* may not have the opportunity and means of satisfying themselves *Experimentally*.

Moschetto.
Artiglieria.

The First Experiment,

Of Sounds *passing equal* Spaces *in equal times.*

Spingarda.
Smeriglio
Mezzo-Cannone.

WE made this *Experiment* in the *Night*, with three several sorts of Pieces, with a *Harquebuss*, a *Falconet*, and a *Demicannon*, planted at Three Miles distance from the place of Observation, whence we could well discern the *flash* of the *powder* in *firing* the *pieces*; from this

flash

flash then, we always counted an equal Number of *Vibrations* of the Pendulum of a Clock, whether the Shot was of the *Harquebuss*, or the *Falconet*, or the *Demicannon*, and that upon all *Levels* and *Directions* of the Barrels of those *Pieces*.

Since *Gassendus* was so taken with that known Example brought by the *Stoicks* to represent to the Life how the invisible propagation of *sounds* is made by the *Air*, we will take this opportunity to consider it: they say, That, as we see standing Water move in *Circles* by casting in a little *stone*, which Waves successively enlarge into greater and greater Rings, till at last they reach the *Bank* of the Water, and there vanish; or dashing themselves against it, are reflected back again: so they assert, That the *air* every way undulates from the *sonorous* Body in successive Circles for an immense space, which Wavings meeting with our *organs* of Hearing, and finding them soft and yielding, impress upon them a certain *Tremour*, which we call *Sound*: hitherto the *Stoicks*, without Prosecuting it any farther: but *Gassendus* was so pleased with the aptness of the *Example*, that he desired to go through with it, and make it capable of explicating the *peculiar properties* of *Sound*; one of which, as was said, is the unalterable *Velocity* of its Motion: whereupon he says, That the undisturbed *Proportion* of the swiftness of *sounds*, agrees with a like *observable* also in the undulations of Water, which he affirms, are neither swifter nor slower, but always with the same degree of *Velocity* approach the Shore, whether made at first by a great or small Stone, whether falling onely with its own *weight*, or forceably cast thereinto: which nevertheless (with due respect to so *great* a Man) we have not found to answer; for we have observed by frequent *Experiments*, that by how much the Stone is *larger*, and the *force* greater, wherewith 'tis thrown into the Water, by so much the *Circles* approach the *shore* swifter.

The

The Second Experiment,
Of Contrary, *and* favouring *Winds.*

THere is another ſtrange obſervable in the Motion of *ſounds*, related alſo by *Gaſſendus*: (*i. e.*) That it is neither *retarded* by a *contrary* blaſt of Wind, nor *accelerated* by a *favouring* Gale; but always travels the ſame ſpace, with an uninterrupted courſe, in the ſame time. This likewiſe we deſired to bring to the *Teſt*, and found it true, thus:

At a Seaſon when the *Weſt* Wind blew, we made Two Diſcharges of two Pieces, one planted *Weſtward*, the other *Eaſtward*, at an *equal* diſtance from the place of *Obſervation*: ſo that the one was favoured by the Wind, the other croſſed; but for all this, they both tranſmitted their *ſound* to the Obſerver in the ſame ſpace of time, meaſured by the equal Number of *Vibrations* of the ſame *Clock*: though indeed, that which was *Eaſtward*, and ſo againſt the Wind, was obſerved much more Languid, than that which was *Weſtward.*

The Third Experiment,
Of the Equability *of Motion in* Sounds.

ONE of our *Academy* took occaſion from thoſe *Experiments* to think, that the Motion of all Sounds might be *equable*, as well as equally ſwift; we arguing, That thence, if true, many curious and profitable hints might be gained: but firſt, to be fully ſatisfy'd if there were really any ſuch

equability,

equability, we made the following *Experiments*.

At the diſtance of one of our *Miles* exactly meaſured, which are about 3000 of our *Braccia*, or 5925 Foot, we fired ſeveral Pieces, that is Six *Harquebuſſes*, and as many *Chambers*; at each whereof from the *Flaſh* to the arrival of the *Report*, we counted Ten whole *Vibrations* of the *Pendulum*, each for which was half a *ſecond*. Repeating the *Experiment* at half a Miles diſtance, that is, at the *mid way*, we obſerved it to be exactly in half the time, always counting at each Report, about five *Vibrations*, wherefore we reſted ſatisfyed of the certainly of this *equability*. *Spingarda. Maſtio.*

The *Conſequences* which we pretend will follow from this *equability*, amongſt the reſt are, That by the Flaſh and Sound of divers *ſhot*, we might obtain an exact Meaſure of the Diſtances of places; particularly at *Sea*, of *Ships*, *Rocks*, and *Iſles*, where we cannot come to take ſeveral *bearings*, as is requiſite in uſing the common *Inſtruments*: we may alſo by a *ſingle* ſtroak made upon *Wood*, *Stone*, or *Metal*, or any other ſounding Body; judge how far off he is that gives the *blow*; telling the *Vibrations* between the ſtroak *ſeen*, and the *hearing* of the Noiſe, which if the Wind be *favourable*, may be heard for ſome *miles*, and it will be eaſie as well as curious, to find the *Diſtance* of *clouds* from us, and of what *height* from the *Earth*, *Thunder* is generated, counting the *Vibrations* between the *Lightning* and the *Blow*.

If we would likewiſe know the *Diſtance* of Places, which becauſe of the *Roundneſs* of the Earth, or interpoſition of *Hills*, we cannot have a ſight of, yet with eaſe we may obtain it, and that by Two *Diſcharges*, anſwering each other; ſo that to our *firing* at one place, they muſt return *another* at the other place; and taking the middle time between our *diſcharge*, and the arrival of their *Anſwer*, the half of the Sounds Journey will be found, that is, the whole *Diſtance* of the Places ſought.

By the ſame way of *ſounds*, the *Maps* of particular Places may be adjuſted, and truly laid down in *plano*; taking firſt the *Angles* of Poſition of the *Cities*, *Caſtles*, and *Villages*,

to place them in their due *ſituation*; with ſeveral the like curious *Inventions* very, uſeful, nor to be diſeſteemed.

Then to gain the unknown Diſtances of each, we may make uſe of time for a Scale, the *ſound* travelling with us the known ſpace of a *Mile* in Five *ſeconds*.

Experiments.

EXPERIMENTS
About
Bodies Projected.

IT was *Galileo's* Opinion, That if a *Culverin* be planted upon the top of a *Tower*, and a Shot be made point-blank (*i. e.*) *Horizontal*, according as the Charge of *Powder* in the Piece is greater or leſs, ſo ſhould the *Ball* fall at a proportionate diſtance of 1000, or 4000, or 6000, or 10000 *Braces*, *&c.* and that all theſe ſhot would be made in equal time to each other, and all equal to the time of the Balls falling from the Mouth of the *Piece* to the Ground, without any impulſe; but onely dropt *Perpendicular*, when there is no accidental hindrance from the *Air*, which may in part impede the ſwift Motion of the *Shot*: we were deſirous to bring this to the *Teſt* of Experience, and it ſeemed to us, that we ſucceeded very well; wherefore we will relate what little Remarkables we can with certainty ſay that we obſerved on this Subject. *Dialog. 2d. de Siſtemi Colubrina.*

The Firſt Experiment,

Of Horizontal *Shot, with a* Falconet *from the top of a* Tower. *Falconet.*

UPon the Top of the *Tower* of the Old *Fortreſs* at *Legorn*, about 94 Foot high, with a *Falconet* carrying an Iron Ball of 7 *l.* ½ with a Charge of 4 *l.* fine *powder*, we made 50 *Brac.*

made ſeveral Shot *Horizontal* into the Sea with the Balls, and obſerved them to fall into the Water at about ⅓ of a Miles Diſtance in 4 ½ *Vibrations*, each whereof was an half *ſecond*: and examining the *Perpendicular* fall of other Balls of the ſame *ſize* from that Height of 50 *Braces*, we found there were 4 of the ſame *Vibrations*.

Their mile is about 5925 f.

The Second Experiment,

With a Demi-Culvering.

Colubrinetta.

With a *Demiculvering* carrying 14 *l.* Ball of Iron, and 10 *l.* of fine Powder, the Balls being wrapt about in 5 of the above-mentioned *Vibrations*, fell into the Water; and without being wrapt about in 5 ½ *Vibrations*; whence it ſeems, that they flew farther than the other.

Faſciate.

Ignude.

The Third Experiment,

Of Perpendicular *Shot with an* Harquebuſs.

Archibuſo

Galileo writes in his Diſcourſe of Bodies *Projected*, Words to this purpoſe: *From the height of* 100, *or more Braces, fire an* Harquebuſs *with a Leaden Bullet Perpendicular to a ſtone Pavement, and with the ſame Charge ſhoot another at the diſtance of one or two Braces upon the like Pavement; examine then which of the two Balls ſhall happen to be more battered; for if that from above ſhall be leſs battered than the other, 'tis a ſign that the* Air *has retarded it, or diminiſh'd the Velocity imparted thereto by the Fire at the beginning of its Motion; and conſequently, that the* Air *will not permit*

Dialogo 4° del Trattato delle 2 nuove Scienze.

permit ſuch a Velocity to increaſe by falling from any great Height. That when the Velocity communicated by the Fire to the Ball, excceds not that which the ſame Ball would naturally acquire by deſcending, the ſtroak of the Ball downward then ought to be rather more violent than faint. I have never made the Experiment (Galileo ſubjoyns) *but am inclinable to think, that the Ball from an* Harquebuſs, *or piece of* Ordnance *coming from any great Height Perpendicular, will not give ſuch a blow, as it will when diſcharged upon a Wall ſome few Braces off* (i. e.) *ſo few, as that ſhort paſſage, or* (we would ſay) *cutting of the* Air, *ſhall not have taken away the Exceſs of the unnatural violence communicated by the Fire.*

We made this trial with a *Harquebuſs*, not firing it againſt a Stone *Pavement* to obſerve the battering of the *Bullet*, but againſt an *Iron Breaſt-plate*, and in this we found that the *Shot* from a leſſer height made a deeper Impreſſion than that from a greater; becauſe as was urged by ſome (after *Galileo*) in a longer Paſſage the Ball loſes continually (by cutting the interpoſed *Air*) ſome of the *Impetus*, and preternatural force received from the Violence of the Fire. *Pettabotta.*

The Fourth Experiment.

That the power of Motion *already impreſt, is not deſtroyed by a new* direction.

IN Confirmation of what *Galileo* Affirms in ſeveral places, *viz.* That the *Virtue* impreſt upon Bodies projected, is not deſtroyed by a new *direction* of *Motion*, it was by ſome propoſed to make the following *Experiment.*

We fitted upon a *Carriage* with Six *Horſes*, a *Saltamartino*, carrying 1*l. Ball* of *Iron*) ſo as it ſtood Perpendicular to the *Horizon*; with this we made divers *Shot* with the ſame quantity of

Three

3 *Danari* Three penny weight of Musket Powder; ſome we made with the *Carriage* ſtanding ſtill, others while it ran a full Cariere upon a Level *Plain*: at the *firſt Trials* the Ball fell near the Mouth of the *Piece*: at the *Second*, after the *Carriage* had run 64 paces from the Firing, to the Return of the *Ball*, it came ſhort of the *Piece* but about 7 ½ Foot, where it
4 *Br.* fell; all the times were very near equal in all the *Trials*.

The Fifth Experiment

Much to the ſame purpoſe.

Baleſtrone. WE made the like *Experiment* with one of thoſe *Croſbows* that are bent with a *Bender*, its Bullet of Lead
Br. 78. weighing Three Ounces, and in 149 Foot Courſe (we mean from the *Diſcharge* to the *Return* of the Ball) it came ſhort
Br. 6. of falling upon the Carriage but 11 ½ Foot, and a Ball of
Br. 100. common *Clay* in running 191 Foot, fell ſhort Three Foot.
Br. 17. ½ Whence ſome confirmed themſelves more in the Opinion of the ſame *Galileo*, That the *Air* takes not a little from the force of heavy Bodies, that cut it, but more ſenſibly of light Bodies.

Miſcellaneous

MISCELLANEOUS EXPERIMENTS.

THough it has been always chiefly endeavoured in our *Academy* to keep a continued Thread of *Experiments* upon what *Subject* ſoever they were made; yet that did not hinder the admiſſion of any particular *Obſervations* as they were ſtill ſuggeſted by any of our *Members*, ariſing from their proper Studies, tho from the deſign then chiefly intended: Now of theſe irregular *Experiments*, there being ſome *Quantity*, ſince they have *little* or no Connection together; altho they may be inſtructive, we have reſerved ſome *Eſſays* of them, like the former, for the laſt place, as a *Concluſion* of the *Work*.

An Experiment,

To know the abſolute Weight *of* Air *in Reſpect of* Water.

THere was taken a Ball of Lead, cloſed every way, and full of *Air*; becauſe this being immerſed in Water, ſwam thereon, we charged it on the outſide with ſo much Lead as ſunk it; and weighing all in exact Scales, we found it 31216 *gr.* being plunged in Water, the ſame altogether weighed but 4672 *gr.* ſo the difference was 26944 *gr.* which was the *abſolute* weight of a *bulk* of *Water* equal to that of the whole *Ball*, and *Lead*.

Then preſſing the *Ball* together, as much as its thickneſs would bear, without letting the *Air* out, and weighing it in the

the *Air* with all the Lead, 'twas found 31209; and this we concluded was the abſolute Weight in uncompreſs'd *Air*, as that was, which was in the *Ball* before it was battered together.

In this *State* all being put into the *water* again, and weighed, 'twas found *gr.* 12518, which ſubſtracted from *gr.* 31209, (the weight of the Ball preſt together in the *Air*) there remained *gr.* 18691, the weight of a *bulk* of *water*, equal to the *bulk* of the ſame *Lead*, and battered *Ball*. This Weight then of *gr.* 18691, being ſubſtracted from the other of *gr.* 26944, left 8253 *gr.* which was the Weight of a *bulk* of *water* equal to ſuch another *bulk* of *Air* as weighs 7 *gr.* (which *bulk* was equal to the diminution of the *bulk* of *ball* by the battering:) whence we concluded, That the Weight of that ſort of *Air* which we weighed, is to the weight of ſo much *water*, as 7, to 8253; that is, as 1, to 1179.

This *Experiment* being by us repeated at divers times, the *Proportion* was not always found the ſame. Indeed, the variations have not been great, conſiſting in one, two, or three Hundreds of *grains*, more or leſs: Which is all we can pretend in making the Compariſon between one *body* that, as we may ſay, never *alters* in its *weight*; and *another*, never twice the ſame.

Experiments

EXPERIMENTS

Touching ſome EFFECTS of *Heat* and *Cold.*

The Firſt Experiment.

Of a Steel Wire, *ſeeming to grow* lighter *by being* heated.

PUtting in the *Eſſay*-Scales two *Steel Wires* of equal Weight, the one *heated*, the other *cold*; it ſeemed that this was heavier than the other: but holding a lighted *Coal*, or red-hot *Iron* near it, it ſoon came to an *æquilibrium* with the hot one. The ſame would have happened if they had been of *Gold*, or *Silver*, or any other *Metal:* likewiſe, if a lighted *Coal* be held over one of the Baſons of a pair of Scales, when empty, it *raiſes* it; and if held under it, it cauſes it to *deſcend.* For all this, ſome of us could not apprehend, how the bare *heating* could any ways alter the uſual *weight* of the *Metal*; nay, 'twas thought by ſome, that the *Preſſure* of the *Air* might have its part as well as any other cauſe, in producing this *Phenomenon.*

The Second Experiment.

Of the vaſt force of Heat *in raiſing up an included* Liquor.

Tab. 19. *Fig.* 3. 1 1/2 *Br.* HAving filled with *Sp. vin.* half of the Veſſel A B, whoſe ſlender part was 35 1/10 Inches long, with two Sealed *Balls* of equal capacity, we ſet the Ball A in a Glaſs of *Oil*, over the *Fire*, and the *Sp. vin.* began to give notice of its *Rarifaction* by Riſing: but afterwards, when the Oyl boil'd very faſt, it retired all into the upper *Ball*, leaving that below quite empty with the lower half of the *Cane*. It is alſo neceſſary to promote this *Effect*, beſides a ſtrong *Fire*, to blow the Coals continually about the Glaſs; (this muſt be done through the hole of a *Plank*, ſerving to defend the *Operator*; behind which alſo the *Obſerver* muſt ſtand to look thorow a Glaſs in the ſame *Plank*) for when the *Sp. vin.* is all forced into the upper Ball, 'twill be thrown off: and not onely that, but the lower will be burſt with ſuch *force*, as one time amongſt the reſt, making uſe of a *braſs veſſel*, inſtead of the *Glaſs*, for the *Oyl*, it broke the *bottom* thereof, and tore off a Band of *Iron* of the thickneſs of a Crown, and crack'd a Stone in the *Pavement*. But we made choice of *Oyl*, and of Glaſs Veſſels; becauſe their *Tranſparency* makes the Procedure of this admirable *Effect* more viſible. Elſe *Wax*, *Pitch*, or *Lard*, or it may be any unctuous Matter may produce the ſame *Effect*.

The Third Experiment, *About* Antiperistasis.

TO do something upon the score of *Antiperistasis*, we filled with *Ice* finely powdered, a Leaden Vessel, and putting thereinto a *Thermometer* of 50 *deg.* we let it stand still, and it composed it self to about 13 $\frac{1}{4}$ *deg.* Then we plunged the Vessel into a *Cauldron* of *boyling Water*, regarding nicely the *Thermometer*, if in that *instant* that the *Ice* became encompass'd with its contrary, it then gave any shew of greater *Cold*, by subsiding. But that, as often as we repeated the *Experiment*, was never seen to alter a *hair:* nor was it ever observed to rise, when the Vessel being full of *hot water*, we plunged it in *water* mix'd with *Ice:* nay, then it was readily seen to *subside*; for as much as the *Fluid water* more easily gave a passage to the Quality of the Ambient, than in the first *Experiment* the *Ice* could do. Nor let it be thought that all the Care possible was not taken to prevent the *Air* Encompassing the *Thermometer* from receiving any alteration, upon immersing the Leaden Vessel in Different *Ambients*, the said Vessel being let into a *Plank*, which was very broad round it, and so cut off all *Communication* between the *bason* under it, whereinto the bottom was immersed, and the *air* above; but for all this, we observed no difference from what is related.

The Fourth Experiment,

Whether Cold *be cauſed by an* intruſion *of* *Frigorific* Atoms.

TO gain ſome light, Whether the *chilling* of Bodies were cauſed by the *inſinuation* of any kind of peculiar *Atoms* of *Cold*, as the opinion is, They are heated by thoſe of *Fire*; we cauſed to be made two Glaſs *Vials* like each other, with very ſlender Necks: being ſealed Hermetically, we put one of them in *Ice*, and the other in hot *Water*; letting them remain ſome time, and then breaking the neck of each, off under *Water*; we obſerved in the *Hot* one a *Surcharge*, or *Repletion* from ſomething got into it, obſervable by the Bubbleing of the *Water*, from a ſtrong breath iſſuing from the *Vial* as ſoon as ever it was broke open. Some might think the ſame ſhould have happened in opening the *Cold* one, if the *Chilling* of the *Air* therein had proceeded after the ſame manner, as the *heating* of that in the other; (*i. e.*) by the *Intruſion* or *ſoaking* of the *Atoms* of *Cold* exhaled from the *Ice*, through the inviſible Pores of the Glaſs: but the quite contrary happened; for inſtead of breathing forth any *ſurcharge* of Matter, it ſhewed an *emptyneſs*, or loſs of ſomething, (if there was not a *condenſation* of what was there) ſince it ſuck'd in ſo much *Water* in place of it.

The

The Fifth Experiment.

Of heating *and* cooling *of* Water *by Salts*, &c. *And of* hot *and* cold Ebullitions, *&c*.

VItriol, the Spirit being drawn off, remains like a *Tartar*, or *Grumous* Body, of a lively *Fire colour*, which with a long and continued *Fire* distills a blackish Oyl, almost like *Inke*, highly corrosive. This being mixt with *Water* in a certain proportion, produces an immediate *Heat*, which increases without raising any *Bubbles*; or perceivable *smoak*, till the Glass wherein this mixture is contained can carce be endured in the hand: the like happens by mixing it with all other Liquids, except *Oyl*, and *Strong* Waters; of which, the *First* is not in the least altered from its *Natural State*: and the *Second*, if a tall, scarce sensibly. *Vetriolo.*

On the contrary, 'tis a known *Experiment*, That *Nitre* dissolved in *Water*, chills it: and *Sal Armoniac* congeals to that Degree, that if in the Water wherewith 'tis mingled in a due proportion, you set a thin Glass of other *Water* (cooled, before well with *Ice*) the *Cold* produced by the said *Salt*, as it dissolves, will *freeze* it. *Sal Nitro.* *Sal Armoniaco.*

Having mingled together one Third part of *Sal Armoniac* and two Thirds of the forementioned *Oyl* of *Vitriol*, there followed an unusual *Effect*: for still as the *Salt* dissolved therein, it *smoaked*, and *boyled* up furiously, and so much the more if we stirred it together with a little Stick, for then it rose up much easierly in *froth*, so as it then filled a space 25 times bigger than the Bulk of the Two separate Bodies, of *Oyl* and *Salt*: but for all this fury of *smoak* and *boyling*, we not onely could observe no sensible beginnings of *heat*, but a strange degree of *Cold* produced therein, chilling the Glass *Cold Ebullition.*

Glass that contained it; and the *Spirit of Wine*, of a *Thermometer* immersed thereinto swiftly subsided, till the *Salt* being dissipated, and evaporated, the *Boyling* ceased, and the *Oyl* returned to its former Natural state.

Such a Production of *Cold* we have known, when ever we have repeated the Experiment; indeed *that*, as well as the *Ebullition* and *smoaking*, is more or less, as the *Salt* is stronger, or the Liquor more refined. We have also observed, That a few drops of *strong Water*, or *Sp.* of *Vitriol* put into the *Oyl* in its greatest fury of *Ebullition*, stops it, and makes the Mixture immediately *hot*; adding Oyl of *Tartar*, the *Heat* is augmented; the *Smoke*, and *Ebullition* returning; but by dropping in of *Sp.* of *Sulphur* it quickly cools again.

Acquarzente. *Sp. di Vetriolo.* *Olio di Tartaro.* *Sp. di Zolfo.*

It is worth a little Reflection: That as *Oyl* of *Vitriol* mixt with all Liquors, *heats* them, (*Oyl* and *Strong Water* excepted) so contrarily *Sal Armoniac* stirr'd together with all Liquors, *cools*, and *refrigerates* them more or less; (*Oyl*, and *Strong-water* likewise excepted, upon which two only 'tis ineffectual:) and again, that upon mixing together, the same *Oyl* of *Vitriol*, and *Sal Armoniac*, there should follow so wonderful a Cold *Ebullition* as is related.

Some

SOME EXPERIMENTS, TO KNOW If *GLASS* and *CRYSTAL* be Penetrable BY *ODOURS* and *HUMIDITY*.

The First Experiment, *Touching* Odours.

OYL of *Wax*, *Quinteſſence* of *Sulphur*, and *Extract* of *Horſes Urine*, which are reckon'd the moſt acute, and ſtrong ſmells that are; do not ſenſibly tranſpire through a Sealed Glaſs *Vial*, as could by many perſons that tryed it, be perceived, tho 'twas *heated*. *Olio di cera Quintes. di Zolfo. Eſtratt. d'orina di Cavallo.*

The *Halitus* alſo of that thin *Spirit* that flies away upon cutting an *Orange*, or *Lemon* Peel, or which in a ſmall Thread ſpins out of the ſame Peel when it is ſqueezed, did not penetrate to give any ſmell to a little *Water* contained in a Criſtal Glaſs Sealed *Hermetically*. *Sp. di Cedrato.*

In like manner, Sealing up a *Partridge* in a ſmall Glaſs Veſſel, and ſetting it in a corner of the Room, and bringing a *Setting Dog* in, we led him round, near the place where it was ſet; but he ſhewed no ſign of perceiving the *Partridge*. *Starna.*

The

The Second Experiment, *Of* Humidity.

A Glass Ball being filled with *Salt*, well ground to Powder, and dryed, was sealed up at the Flame of a Lamp, and put for ten days at the bottom of a *Cistern* of *Water*; and after that, as long in a *Conservatory* of *Snow*; but it did not increase at all in Weight; and when broken, the Salt was taken out so dry, that it fell to powder.

Yet we have sometimes chanced to find in the Ball of Salt some little part thereof dampish; but we can not argue a *Penetration* from thence; for if it were really so, it ought not to be more in one place than another; whereas, that little moisture being always found in one place, 'tis very probable it was onely a little of the *Humidity* which the force of the Cold drove out of the *Air* remaining in the Ball, and sticking as a Cover to the inside thereof.

Some

SOME EXPERIMENTS Concerning *LIGHT*, and its *EFFECTS*.

The First Experiment, *Of the Instantaneous* Motion *of* Light.

Galileo in the First Dialogue of his *Treatise* of *Two New Sciences*; suggests an easie way to discover, Whether *Light* moves in time, or with an *Instantaneous Velocity*: the Trial consists in the *Confederacy* of Two Companies of Men to expose Two *Lights* to each others *view*, so that the discovery of the one, may answer immediately to that of the other: that when the one uncover their *Light*, and expose it, they may at the same time perceive the *Light* of their *Confederates*. This being often practised at a small distance *Galileo* desired to have the same tryed by observers at a greater Distance; to see, if the mutual *Correspondence* of Exposing and Covering their *Lights*, kept the same Measure as when nearer; that is, without any observable *Delay*. Pag. 43. Edit. Lugd. 1638.

We tryed it at a Miles distance (which in the going forward, and Return of the *Light* must be reckon'd Two, and could not observe any. If in a greater *Distance* it be

possible to perceive any sensible *Delay*, we have not yet had an opportunity to try.

The Second Experiment,

Of Fireing *Bodies with a* Burning-glass.

THE *Light* Refracted by a Crystal *Lens*, or reflected by a Burning *Concave*, will not fire *Spirit* of *Wine*, tho made *opaque* by a *Tincture*. Amongst other combustible matters, *Gunpowder* fires upon the uniting the *Rays* of a *Lens* or *Concave*. But the Perfumed *Pastils*, white *Balsame*, *Storax*, and *Incense*, melt, but will never take *fire*.

Acquarzante. *Pastiglia.* *Balsamo Bianco,* &c.

Likewise *Paper*, and fine white *Holland*, when exposed flat to the *Reverberatory* of a large *Concave*, at length Fire: wherefore 'tis a mistake, that the *Light* will not inflame any *white* Bodies, as is generally thought; indeed they take Fire with more *Difficulty*, than *Coloured* Bodies, and it may be with a small *Concave* or *Lens* they will not Fire.

The Third Experiment.

Of Bodies affording Light.

BEsides *Fire-stones*, there are other Bodies that seem to be greater *Conservatories* of *Light*; for by striking them together, or by breaking them in the *Dark*, they *Sparkle*. Such are *White-Sugar*, *Loaf-Sugar*, and *Sal-Gemme* in the Stone; all which being broken in a *Mortar*, give forth so great a *Light*, as distinctly to discern the sides of the *Mortar*,

tar, and the ſhape of the *Peſtle* thereby: but we have not ſucceeded to ſee the ſame appearance in pounding Common *Stone-ſalt*, *Alumn*, or *Nitre*; nor in *Coral*, the *Yellow* or *Black Amber*, *Granats*, or *Marchaſites:* But *Rock-Chryſtal*, and *Agate*, and *Oriental Jaſper*, either ſtruck together, or broken, give a clear Light.

EXPERIMENTS ABOUT *The* Digeſtion *of ſome* Animals.

WOnderful is the Force wherewith the *Digeſtion* of the *Hen*, and *Duck*-kind is performed; for they being crammed with little Balls of Solid *Cryſtal*, were diſſected by us in a few *hours*, and opening their *Ventricles* in the *Sun*, they ſeemed to us covered all over with a glittering *Coat*, which examining with a *Microſcope*, we found it to be onely ſtrewed over with exquiſitely fine and impalpable powder of *Cryſtal*.

In others, likewiſe crammed with hollow Bubbles of *Cryſtal-Glaſs* with a ſmall hole in them, we were amazed to find of the ſaid *Bubbles* ſome already broken, and powdered; others onely crack'd, and filled with a *Whitiſh* Subſtance, like curdled *Milk*, got in at the ſmall hole; and we alſo obſerved, that thoſe were better *powdered*, (than the others) which had in the *Maws* with them a greater *Quantity* of ſmall Stones. And 'tis leſs ſtrange, that they break, and grind to *pieces*, *Corke*, and any hard *Woods*, as *Cypreſs*, and *Beech*, and rub to Powder *Olive-ſtones*, the hardeſt *Pine-Apple* Kernels, and *Piſtackes* put down their Mouths, with the Husk on. *Piſtol bullets* in Twenty four Hours we have found much *Battered*; and ſeveral little hollow ſquare Boxes of *Tin* were obſerved to be ſome *ſcratched*, and battered, others tore open from one ſide to the other.

FINIS.

A TABLE OF The Principal Matters Contained in this Work.

A.

The Table.

B.

C.

D.

Table

E.

F.

Made

G.

H.

The Table.

I.

L.

M.

N.

O.

And

S.

The Table.

T.

V.

Hindered

W.